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THESIS

THE IMPACTS OF ACADEMIC BACKGROUND ON SUBMARINER PERFORMANCE, RETENTION, AND PROMOTION

by

Eric P. Woelper

March 1998

Thesis Co-Advisors: Stephen L. Mehay
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This thesis analyzes the relationship between pre-commissioning academic background and submarine officer performance. Four measures of officer performance are used: (1) probability of completing the nuclear training pipeline; (2) probability of receiving an early promotion recommendation on greater than 75 percent of LT fitness reports; (3) probability of remaining in the Navy for 10 years of commissioned service (until the O-4 board); and (4) probability of promoting to LCDR. Navy Promotion History files, Officer Data Cards, Fitness Report files, and Loss files are used to statistically analyze the impacts of college grades and major, college quality, and commissioning source on submariner performance and retention. Non-linear maximum likelihood techniques are used to estimate the four performance models. The findings reveal that good grades and engineering majors have a significant positive impact on all four performance measures including retention. There are exceptions among OCS graduates. Grades have an insignificant effect on the probability of completing the training pipeline and of remaining in the Navy until the O-4 board. Also, non-technical majors are more likely to remain in the Navy than engineering majors. USNA graduates fare best on all performance measures with the exception of completing the training pipeline. ROTC graduates generally fare better than OCS graduates. Among ROTC and OCS graduates, greater college selectivity leads to higher performance but lower retention rates for OCS graduates. There is no difference in retention rates for ROTC graduates with respect to college selectivity.

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THE IMPACTS OF ACADEMIC BACKGROUND ON SUBMARINER PERFORMANCE, RETENTION, AND PROMOTION

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

This thesis analyzes the relationship between pre-commissioning academic background and submarine officer performance. Four measures of officer performance are used: (1) probability of completing the nuclear training pipeline; (2) probability of receiving an early promotion recommendation on greater than 75 percent of LT fitness reports; (3) probability of remaining in the Navy for 10 years of commissioned service (until the O-4 board); and (4) probability of promoting to LCDR. Navy Promotion History files, Officer Data Cards, Fitness Report files, and Loss files are used to statistically analyze the impacts of college grades and major, college quality, and commissioning source on submariner performance and retention. Non-linear maximum likelihood techniques are used to estimate the four performance models. The findings reveal that good grades and engineering majors have a significant positive impact on all four performance measures including retention. There are exceptions among OCS graduates. Grades have an insignificant effect on the probability of completing the training pipeline and of remaining in the Navy until the O-4 board. Also, non-technical majors are more likely to remain in the Navy than engineering majors. USNA graduates fare best on all performance measures with the exception of completing the training pipeline. ROTC graduates generally fare better than OCS graduates. Among ROTC and OCS graduates, greater college selectivity leads to higher performance but lower retention rates for OCS graduates. There is no difference in retention rates for ROTC graduates with respect to college selectivity.

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I. INTRODUCTION

> I think teaching management as a major subject for an undergraduate is ridiculous and I can see no way that it contributes to the ability of a junior officer to do his job.... All midshipmen should take a common core of subjects taught at the same academic level. Electives should be offered if time in the program of core subjects can be found, but these electives should be rigidly limited to those which will prepare midshipmen for their role as naval officers. The social sciences should be specifically excluded.
>
> -- ADM Hyman G. Rickover, Director of Naval Reactors and "Father of the Nuclear Navy", on the newly instituted majors program at the Naval Academy, made during a 1976 hearing before the House Armed Services Committee.

This study tests Admiral Rickover's hypothesis and the submarine force's continued emphasis that a strong technical background best prepares an officer for success as a submariner.

A. BACKGROUND

The DOD and DOE handbook on naval nuclear power proudly states, "100 million miles safely steamed on nuclear power." Jealously proud of its pristine operating record and keenly aware of the public outrage that would follow a nuclear accident aboard a United States submarine, the submarine force depends on the capabilities of its officers and sailors to maintain its perfect operating record.

The intricacies of nuclear power require officers with a high degree of technical aptitude and the ability to rapidly comprehend and respond to systems casualties. Since the advent of naval nuclear power, the submarine force has sought college students who possess a strong academic record and a high degree of technical aptitude to become

submarine officers. This study finds that approximately 90 percent of submarine officers graduated with "technical" majors in math, science, or engineering. Approximately 60 percent graduated with engineering majors. In addition, this study finds that 48 percent of submariners achieved above a 3.20 grade-point-average (GPA), compared to only 16 percent for other unrestricted-line (URL) officers.

This study examines the effect of academic background on officer performance and retention in the submarine force. It focuses primarily on the effect of academic achievement as measured by grades and undergraduate major, and additionally analyzes the effects of college quality and commissioning source. The research draws on various aspects of human capital theory, including: returns to investment in formal education and training, general versus specific training, and selecting the career that maximizes lifetime earning potential.

Numerous studies of returns to investment in human capital have demonstrated that the more educated earn more than those with less education. Our education system assigns grades based on an individual's mastery of the subject, and grades are often used as a tool to select individuals into certain occupations. However, several authors have concluded that grades have little effect on measure of adult accomplishment. Also, individuals are rewarded on the selectivity, presumably quality, of their college alma mater. Graduates of more selective institutions tend to earn more money than graduates of less selective institutions. The assumption is that the more selective institutions provide a better education and have already screened and selected only the most capable

individuals. A classic study found that college grades and college quality have a positive impact on productivity. (Wise, 1975)

The theory of human capital investment, discussed in detail in Chapter II, suggests that formal education and training increases productivity and earnings of an individual over time. Due to the general lack of data on worker productivity, most studies have focused on increased earnings on the assumption that increased productivity leads to greater pay. In the military, increased earnings result only from promotion, which is infrequent, and length of service. However, the military's performance evaluation and promotion system provide a metric by which to measure an individual's productivity. Analyzing productivity rather than earnings directly tests the theory that formal education increases productivity. This study utilizes the military's performance evaluation and promotion system to analyze the effects of formal education and training on productivity.

Additionally, human capital theory states that there are two types of training: *general training* that increases an individual's productivity *to many employers* equally, and *specific training* that increases an individual's productivity *only at the firm* in which he or she is currently employed (Becker, 1975). In this study, there are two levels at which to consider general versus specific training. From the Navy's perspective, officer candidates receive general training in the form of an undergraduate major which is useful to employers other than the Navy and specific training in the form of naval indoctrination which is only useful to the Navy. The submarine force's perspective is nearly opposite. Naval indoctrination serves as general training which is useful to all naval warfare communities, and undergraduate majors (at least engineering majors) serve as specific

training which prepare submarine officers for the technical complexities of nuclear power. This study analyzes the effect of undergraduate major on performance as a submarine officer.

Human capital theory also states that an individual chooses the occupation and level of education that maximizes the present value of his expected lifetime earnings. This study assumes that officer candidates select a warfare community based on which community best matches their individual talents and interests. However, the various commissioning sources do not provide equal amounts of job information.

Officer candidates enter the submarine force from three main commissioning sources: the United States Naval Academy (USNA), the Naval Reserve Officer Training Corps (NROTC), and the Officer Candidate School (OCS). Approximately one-third of submarine officers graduate from each of these sources. A fourth source, no longer in existence, the Navy Enlisted Science and Engineering Program (NESEP) commissioned approximately three percent of submarine officers from fiscal year 1977 to fiscal year 1985.

USNA and NROTC midshipmen enter college with the expectation of becoming an officer following graduation. They are indoctrinated into "Navy life" over a four-year period and participate in several one-month summer cruises aboard naval vessels. The summer cruises familiarize midshipmen with the Navy's warfare communities and enable the midshipmen to select the community which best matches his interests and abilities.

OCS graduates, on the other hand, are recruited into the nuclear navy during their last few years of college. Virtually all enter the Navy through the Nuclear Power Officer

Candidate (NUPOC) program. Their indoctrination consists of a three-month training program following college graduation and a one-day tour of a submarine and submarine base. Many had no desire to enter the military at the time they entered college and chose to commit to service in the Navy after a couple of years at college. OCS graduates were older, more mature, and seemingly better-informed about their job prospects following college by the time they committed to service in the Navy. Based on human capital theory, it is assumed that the Navy provided the greatest expected earning potential to the OCS graduates. However, it is expected that the OCS graduates selected the submarine community (vice other naval communities) based on less information than USNA and NROTC graduates.

NESEP graduates are prior enlisted members who were selected from the ranks to become an officer. The NESEP program has been replaced by the Nuclear Enlisted Commissioning Program (NECP) which is a part of the navy's Enlisted Commissioning Program (ECP). This study will not focus on NESEP graduates as they compose such a small percentage of submarine officers.

Nobody denies the submarine force's need for intelligent officers with a strong technical background. However, college students with good grades, particularly those with technical majors, are difficult to recruit and may be less motivated to stay in the Navy due to greater civilian employment opportunities. This study sought to determine if good grades and a strong technical background are actually the ingredients necessary for success as a submariner.

B. OBJECTIVE

The objective of this thesis is to measure the impacts of college grades, undergraduate major, college quality, and commissioning source on submariner performance and retention. Three measures of performance are used: successfully completing the nuclear training pipeline; likelihood of being RAP'd (recommended for accelerated promotion) on greater than 75 percent of O-3 (LT) fitness reports; and promotion to O-4 (LCDR). Utilizing multivariate modeling techniques, the intention is to test the "Rickover hypothesis" that a strong technical background best prepares naval officers, especially submarine officers, to handle the complexities of modern technology. The primary goal is to determine if good grades and a strong technical background are actually the ingredients necessary for success as a submariner. Also, due to the fact that it is difficult to retain officers who possess stellar academic records, particularly those with technical majors, the study analyzes the likelihood that an officer remains in the Navy through ten years-of-service (until the O-4 board) based on the same explanatory variables.

This study is intended to provide recruiters, who recruit college students into the NUPOC program, information about what type of college student (based on academic background) is likely to perform well and is likely to remain in the Navy. The analysis is performed first for the combined population, then separately for OCS graduates, and for USNA and NROTC graduates combined. These sub-samples were created to determine whether the effects of academic background are different for OCS graduates than for USNA and NROTC graduates.

The nuclear navy's investment in submarine officers is significant. It is difficult to recruit the type of college student that the submarine force desires, requiring larger recruiting budgets and enticing signing bonuses. Also, this type of college student is more difficult to retain due to greater employment opportunities, and therefore large bonuses are required to maintain necessary force levels. The results of this analysis will address the validity of the submarine force's current emphasis on good grades and a strong technical background.

C. SCOPE, LIMITATIONS, AND ASSUMPTIONS

The focus of this study is on the effects of academic background on submariner performance and retention. The effects of other college characteristics, such as participation in athletics or other extracurricular activities, are not included. As stated before, the intention is to test the validity of the "Rickover hypothesis" and provide recruiters with information that will allow them to focus on college students who are likely to perform well and remain in the Navy. Recruiters have little information other than an individual's academic background and do not assess an individual's psychological ability to endure the hardships of life as a submariner. It would be interesting to analyze the effects of other college characteristics; however, the database used in this study does not include information concerning any college characteristics other than academic background.

Also, the effect of post-commissioning factors, such as: marital status, type of ship served on, assigned duties, and length-of-time required to complete various qualifications

are ignored. Although these factors significantly affect an individual's performance and desire to remain in the Navy, the intention is to analyze the effects of explanatory variables that can be used by the recruiter. Additionally, no data was available to control for the commissioning source of the reporting senior, the senior officer that evaluates an officer on his fitness reports. Therefore, institutional bias[1] may exist.

The study is limited to the submarine force due to the unique nature of the typical submariner. The submarine community is the only naval warfare community that utilizes academic screens to select which officer candidates it desires, and therefore the typical submarine officer has much better grades and a stronger technical background than the typical officer in other naval communities. The validity of the "Rickover hypothesis" is tested on the community that places the greatest emphasis on a strong technical background and has the luxury to exclude officer candidates with weaker academic records.

Current analysis techniques do not allow us to differentiate the individual effects of the cognitive abilities gained as a result of an officer's undergraduate major from his inherent abilities. However, the intent of the study is to analyze the collective effect of undergraduate major (acquired and inherent abilities) in order to determine which major produces the most capable submariners, not just which provides the best preparation. Also, there is no attempt to determine why better grades lead to better performance. This study is not concerned whether it is because students with better grades are actually more

[1] Institutional Bias, informally known as the "Old Boy's Network", is the notion that a Naval Academy graduate will tend to assign more favorable grades to junior officers who are also Naval Academy graduates.

capable or are just more motivated. The focus is on the information available to a recruiter. Recruiters have access to college grades, but do not have access to an analysis of how a student earned his grades.

To ensure there are no missing values for any variables, only submariners with complete data on all variables are included in the analysis.[2] Also, only officers who were commissioned into the submarine community are included in the analysis. Although only 315 officers, or 8.8 percent, transferred into the submarine community after commissioning, the intent is to analyze the effects of academic background on just the officers who were initially recruited to be submarine officers, testing the policies used to screen candidates for the submarine force.

The model that measures an officer's performance as an O-3 suffers from additional missing values. Because the model measures performance based on O-3 fitness reports, the sample excludes officers for whom O-3 fitness report information is not available.[3] An analysis of the observations with missing values indicates that there is little or no systematic relationship with any of the explanatory variables. There is, however, a significant relationship with the other dependent variables. Of officers with no O-3 fitness report information, 88 percent left the Navy prior to their O-4 board, compared to 55 percent of officers with information. Of those who stayed until their O-4 board, 41 percent of officers without O-3 fitness report information promoted to LCDR, compared to 81 percent of those with information. Due to little correlation between missing O-3

[2] This process resulted in 959 of 4526 officers commissioned as a submariner (21 percent) being excluded from the study.
[3] This process resulted in 477 of 3076 submarine LT's (15.5 percent) being excluded from the study.

fitness report information and the explanatory variables; and, in order to prevent overly small sample sizes, no officers were excluded from the other models based on missing O-3 fitness report information.

Measuring the likelihood of completing the nuclear training pipeline is based on the assumption that an officer who transfers out of the submarine community between commissioning and the O-3 board, at approximately three years-of-service, failed to complete the nuclear training pipeline. This assumption should hold true for a significant majority of the officers who transferred to other communities.

Finally, the analysis suffers from small sample sizes. The whole population is of sufficient size, but some of the groups within the population are relatively small. For example, humanities majors make up only two percent (74 out of 3567) of the whole submarine officer population. Less than ten percent of submariners graduated with degrees in non-technical (social sciences, management, and humanities) areas.[4]

D. ORGANIZATION OF THE STUDY

This study is organized into five chapters. Chapter II reviews various aspects of human capital theory, information concerning submariner recruitment and career progression, military fitness reports and promotion boards, and previous studies which have analyzed the returns to human capital and the use of military fitness reports as a

[4] The smallest subset is analyzed in the promotion model using only graduates of the NUPOC program. There are 292 observations in this subset. 227 (81 percent) promote to LCDR. The effect of a humanities major was found to be significant despite the fact that only 24 officers (eight percent) graduated with a humanities major.

means of measuring productivity. Chapter III describes the data used in this thesis and discusses the specification of the various multivariate models used to analyze the effects of academic background. Chapter IV presents the results of initial descriptive analyses and more complex regression analyses using multivariate models of retention and performance. The marginal effects of the explanatory variables are also discussed in Chapter IV. Chapter V provides conclusions and recommendations on further research. Appendix A lists the complete analytical results, including probit coefficient estimates, chi-square values, and level-of-significance of each variable. Finally, Appendix B lists the distribution of submarine officers among the various categories. It includes both the actual numbers of officers and the corresponding percentage in each category.

II. LITERATURE REVIEW

This Chapter reviews various labor economics theories used in this study. These include theories of "human capital," "screening," and "self-selectivity." Additionally, this chapter provides information concerning career progression in the submarine force, and the military's officer evaluation (fitness reports) and promotion system. The chapter ends with a review of several studies relevant to issues covered in this study.

Very few studies have analyzed the effects of human capital on productivity using firm-level data. Most of these studies suffered from the lack of a direct measure of job productivity and following the labor market theory that workers are paid according to their marginal productivity, most of these studies used salary or hourly wages to estimate job productivity. However, in many cases, the studies failed to provide information on the structure of the personnel system. Despite the use of earnings as a measure of an individual's productivity, no information was given about promotion between grades or other means by which an individual increases his earnings.

This study, however, utilizes data that directly measures the productivity of a submarine officer. It examines the effect of college academic background on job success using a unique micro database consisting of naval officers. The data set contains relatively detailed information on the promotion outcomes, performance ratings by supervisors, and numerous background characteristics such as college grades and major, and prior performance in the organization. An advantage of the data set in exploring worker productivity is the organization's well-defined personnel system and career paths. The

military is characterized as a vertical hierarchy with a well-developed internal labor market. All officers are in managerial and professional positions, and start their careers in entry-level positions with a bachelor's degree. Also, all are subject to an up-or-out screen at a certain point in their careers. The advantages of using data for personnel in a single organization is that the research design controls for huge differences in personnel structure, career paths, job assignment policies, and incentives. (Mehay and Bowman, 1997b)

The impacts of academic background are important to the Navy, because the Navy expends great effort and resources to recruit and retain officers with the intellectual ability and technical aptitude necessary to succeed as submariners. An increase in each of the measures used in this study to estimate academic background (college quality, college grades, and technical aptitude as measured by college major) results in an individual who has greater employment opportunities available to him. Therefore, he becomes more difficult to recruit and seemingly more difficult to retain.

A. THEORETICAL BASES

This study draws on various aspects of human capital theory, including: returns to investment in formal education and training, general versus specific training, and selecting the career that maximizes lifetime earning potential. Theories in labor economics based upon the use of education as a screening device and self-selection bias are also utilized.

1. Human Capital Theory

Investments, by definition, entail an initial cost that one hopes to recoup over some period of time. "Investments in human capital" refer to initial costs incurred by an individual with the expectation that the investment will pay off in the form of higher productivity (leading to higher earnings), reduced job turnover, and greater job satisfaction. Human capital investments include education and training, migration, and searching for new jobs.[5] (Ehrenberg, 1994) This study will focus on the effects of education and training.

An individual is assumed to make personal investments in schooling, vocational training, and (firm-specific and general) on-the-job training (Becker, 1960). Human capital investments will be undertaken as long the expected returns, in the form of enhanced earnings, long-term job opportunities, and job satisfaction, exceed total cost incurred. Both quantity and quality measures of human capital are approximated in this study by the choice of academic major and grades earned. Grades are assumed to be a measure of an individual's mastery of the subject material, and therefore the quality of the human capital gained. (Bowman, 1990)

The introductory chapter briefly mentions the difference between general vs. specific training. General training increases an individual's productivity to many employers equally, and specific training increases an individual's productivity only at the

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[5] Human capital investment in education and training results in initial costs in the form of tuition and forgone earnings during the period of education.

Migration and Job Search are activities that result in lost wages and moving costs, but increase the value of one's human capital by increasing the price (wage) received for a given stock of skills. (Ehrenberg, 1994)

firm in which he or she is currently employed. Submarine officers receive general training in the form of management and leadership experience, and a college education. Specific training consists of naval indoctrination from each of the commissioning sources and the nuclear power training pipeline for one-and-a-half years following commissioning. The training program is described later in section B of this chapter. An engineering major also serves as a form of specific training as it increases an individual's degree of technical aptitude, preparing him for the complexities of nuclear power.

Human capital theory explains that employers are more willing to pay for an employee's specific training rather than general training. Assume an employee's marginal productivity equals MP_1 before training and increases to MP_2 after training.[6] The employee is paid wage W_1 when his productivity equals MP_1. After training, the employee's productivity increases to MP_2, and one would expect that the employee's wage would increase to W_2 commensurate to his increase in productivity. However, the employer must recover the cost of the training, assuming the employer paid for the training. Therefore, the employee's wage will increase to W_* which is less than W_2. The difference between the employee's worth to the company and the employee's wage allows the employer to recover training costs. If the training was specific, the employee's worth to other employers remains at the pre-training level of MP_1, and the employee remains with the current employer because his current wage (W_*) is greater than the wage (W_1) he could earn from other employers. However, if the training was general, the employee's

[6] Equations relevant to discussion: $MP_1 = W_1$, $MP_2 = W_2$, $MP_1 < MP_2$, $W_1 < W_* < W_2$

worth increases to MP_2 for all employers. Therefore, since $W_* < W_2$, the employee will be likely to quit because he can demand wage W_2 from other employers.

Because submarine officers have earned better grades and displayed greater intellectual ability than the average officer in other naval communities, it is evident that they possess greater amounts of human capital. The Navy realizes the worth of submarine officers to employers other than the military, and pays financial bonuses to improve retention. The Nuclear Officer Incentive Program (NOIP) was initiated in June 1969 to combat the chronic shortage of nuclear-trained submarine officers. Over the years, authorization for the NOIP program has been expanded and annual payment amounts have also increased (Nakada and Boyle, 1996). An officer receives Continuation Pay (COPAY), $12,000 per year, if he agrees to remain in the nuclear navy for a term of three, four, or five years. Alternatively, an officer who does not sign a contract receives an Annual Incentive Bonus (AIB), $10,000 per year, for each year he remains in the nuclear navy. Additionally, officer candidates are paid an accession bonus of $6,000 when they agree to enter the nuclear navy. The payments were increased to the current level in August 1996. (Feeley, 1996)

Both quantity and quality measures of human capital are approximated in this study by college major and grades. It is assumed, for example, that a greater quantity of specialized training is acquired by an engineering major relative to a humanities major, while an engineering major with superior grades in engineering courses possesses a greater quality of human capital than do others in his major. A similar argument could be made with regard to more general training for those majoring in the humanities. The model

assumes that the quantity and quality of specialized and general training determine which graduates are more likely to perform well as submarine officers. The impact on rate of retention of the two types of training acquired in college is ambiguous, however. While general training obviously has applicability to all jobs, it is also true that specific technical training acquired in college has applications in occupations found in both the military and civilian labor markets. As such, it is not clear whether the more technically oriented graduate is more or less likely to remain in the Navy than is the less technically oriented graduate. (Bowman, 1990)

Human capital theory states that an individual chooses the occupation and level of education that maximizes the present value of his expected lifetime earnings. "Earnings" refers to more than just financial compensation. It also refers to intrinsic forms of compensation such as job satisfaction and quality-of-life. This study assumes that USNA and NROTC graduates have selected the submarine community as the best option among the naval warfare communities, whereas OCS graduates selected the Navy and the submarine community as the best option among a wider range of employment opportunities, including civilian employment.[7] This study also assumes that the typical college student selects the major that maximizes his utility. Therefore, he selects a major that provides the best combination (for him) of matching his skills, his work ethic, his interests, and his expectations for future employment.

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[7] This assumption is based on the fact that USNA and NROTC midshipmen are required to enter the Navy following graduation, and therefore must select an occupation from among the naval warfare communities. OCS graduates, on the other hand, agree to enter the nuclear navy during their junior year of college or later. The Navy is one of many employers the OCS graduate could choose.

This thesis explores the hypothesis that individuals who decided to attend USNA were more serious about a career in the Navy as they entered college than those that were commissioned NROTC and OCS. Individuals commissioned through NROTC were willing to enter the Navy following graduation from college, but chose not to accept the loss of freedom and hardships associated with military life at USNA. Virtually all submariners who were commissioned through OCS had been recruited into the nuclear navy during their junior or senior year of college. Many had no desire to enter the military at the time they entered college and chose to commit to service in the Navy after a couple of years at college. This can have opposite effects on performance as an officer and retention. OCS graduates were older, more mature, and seemingly better-informed about their job prospects following college by the time they committed to service in the Navy. However, an OCS graduate may view service in the Navy as best of a list of poor job prospects following college graduation.[8] The typical OCS graduate did not display a propensity for military life before entering college, but may have considered the nuclear navy a good stepping stone to future employment.

2. Screening And Internal Labor Markets

The use of screening devices is an inexpensive method for employers to minimize hiring costs while maximizing productivity. However, a major problem with the use of credentials, or screening devices, to predict which applicants will become good employees

[8] The officers analyzed in this study entered the Navy from 1977 to 1985. Unemployment rates were much higher during this time than now, and college graduates did not have the tremendous range of employment options that are currently available to graduates.

is that these credentials may only be loosely related to retention or actual productivity on the job. Such personal attributes as dependability, motivation, honesty, and flexibility are difficult to observe using credentials, yet for many jobs such attributes are crucial. This difficulty with screening has induced some firms to adopt a policy of hiring workers at low-level jobs, observing their behavior, and filling all upper-level jobs from within the firm. (Ehrenberg and Smith, 1994)

Hiring employees only at entry-level positions creates an internal labor market because most jobs in the firm are filled from within the ranks of current employees. Employers hire workers into low-level positions where a less productive employee cannot cause too much harm and more productive employees can be identified and promoted. This ensures that higher level positions are filled only by proven employees, but it also restricts the pool of applicants for higher positions. Employees in the firm may not be the best employees available, but they are the only ones considered for these jobs. Firms most likely to decide that the benefits of using an internal labor market outweigh the costs are those whose upper-level workers must have a lot of firm-specific knowledge and training that can best be attained by on-the-job learning over the years. (Ehrenberg and Smith, 1994)

The submarine officer community can be characterized as an internal labor market as all officers enter at the lowest level. Some officers transfer into the submarine community after commissioning, but they must complete the training pipeline and enter the submarine community at the lowest level. It would be difficult, if not impossible, for an officer to become a successful commanding officer of a submarine without an entire career

as a submarine officer. Therefore, it is important for the submarine community to identify useful screening devices for selecting officer candidates.

There are debates over the returns to college education concerning whether the education actually increases an individual's cognitive skills or if it merely serves as a screening device to indicate which students have the motivation and skills necessary to complete a college degree. Those that argue it serves merely as a screen point out the fact that rates of return for college graduates are higher than for college dropouts. Because there is a sudden increase in earnings when a diploma is earned, they argue that the diploma serves as a screening device. On the other hand, those that believe schooling enhances human capital, argue that one who graduates after four years probably has learned more than four times what the freshman dropout has learned. They argue that dropouts are more likely to be poorer students—the ones who overestimated their returns on schooling and quit when they discovered their mistake. (Ehrenberg and Smith, 1994)

This study does not analyze whether a diploma serves as a screening device, but instead looks at commissioning source and the use of college grades and major as a screening device. Because all officers in this study possess a bachelor's degree, a college diploma does not serve as a screening device, but college major and grades may. The nuclear navy values technical aptitude, and primarily seeks candidates from technical majors. However, any student who has displayed above-average academic ability, through good grades, has the potential to be selected by the submarine community.

3. Self-Selection

Self-selection is another important issue. As shown in Table 2.1, over 90 percent of submarine officers graduated with a technical degree (i.e., engineering, mathematics, or physical sciences), compared with just 53 percent in other warfare communities. In addition, 48 percent of submariners achieved above a 3.20 grade point average (GPA) as compared with only 16 percent of officers in other warfare communities. Since technical majors and academic performance vary by service community selection, failure to account for screening and self-selection could bias the evaluation of the relationship between academic schooling and fleet performance and retention.

Table 2.1 Percent Distribution of Graduates Across Warfare Communities By Academic Major and Achievement by Graduates in Various Majors Categories[9]

	Submarine Community (N=3,567)	Other URL Communities (N=15,973)
Academic Major		
Biology/Physical Sciences	21.2	16.5
Math/Computer Science	9.4	9.8
Engineering	60.7	26.7
Social Sciences	3.3	16.8
Management	3.3	20.0
Humanities	2.1	10.2
Grade Point Average		
All Majors		
>3.20	48.3	16.4
>2.60	93.7	59.6
Bio/Phy Sciences/Math/Comp Sci		
>3.20	54.3	15.5
>2.60	95.2	57.6
Engineering		
>3.20	46.1	16.9
>2.60	93.7	58.5
Soc Sci/Management/Humanities		
>3.20	42.9	16.6
>2.60	88.0	61.5

[9] All figures drawn from the database used in this study.

First, students select which commissioning source to attend and what course of study (college major) they wish to pursue. Second, service selection from USNA and NROTC is based on an individual's standing in his class rank so that higher achievers and those more motivated may self-select into the submarine force, as it has come to represent the "cutting edge" and presents the greatest intellectual challenge for future Navy leaders. Finally, graduates with more extensive technical training and/or superior performance in technical courses may be viewed as having greater quantities of specific human capital relevant to the submarine force and are therefore favored by the nuclear power selection board.

This study does not attempt to isolate the portion of the error term caused by self-selection. Because this study is interested in what type of person and what type of preparation fares best in the submarine force, it is desirable to include the effects of self-selection bias as part of the effect of the explanatory variables. Moreover, it is not possible to isolate the effect of an individual selecting a certain major or commissioning source because information is not available to explain why the selection was made.

There seems to be two opposite influences on the effect of selection bias (with regards to undergraduate major) in this study. Because students who inherently have a high degree of technical aptitude are more likely to select engineering majors, the value of an engineering major will be overstated. However, the students with non-technical majors who are selected to be in the submarine force are not the typical liberal arts major. Officials at Naval Reactors in Washington, D.C. interview all candidates regardless of major, grades earned, or commissioning source prior to selecting which students to

accept. The interview process consists of two one-on-one technical interviews designed to assess a candidate's degree of technical aptitude. Therefore, candidates with non-technical majors will have demonstrated an acceptable level of technical aptitude and impressed the officials at Naval Reactors with other factors such as command presence and personality. This screening process understates the effect of an engineering major because of the exceptionally high quality of candidates accepted from liberal arts majors.

B. CAREER PROGRESSION, FITNESS REPORTS, AND PROMOTION

The submarine force draws approximately one-third of its officers from each of the three main commissioning sources: USNA, NROTC, and OCS. Because all naval officers possess at least a bachelor's degree, the submarine force does not use possession of a college degree as a screening device, but instead uses the type of degree and the level of grades earned. The submarine force considers it imperative that all submarine officers demonstrate a high level of technical aptitude. Therefore, it seeks primarily college students with engineering degrees, and sets minimum requirements for college physics and calculus courses.[10] College major and grades are used as an initial screen to identify students who are likely to possess the necessary level of technical aptitude, but do not

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[10] COMNAVCRUITCOMINST 1131.2A, the Naval Recruiting Command's Instruction for recruiting college students into the NUPOC program, requires:

(1) Calculus. One year i.e., two semesters, two trimesters, or three quarters of college calculus through differential and integral calculus of one real variable with a "B" average or better grade (a "C" average or better if the candidate is in a physics, math or engineering curriculum major...).

(2) Physics. One year i.e., two semesters, two trimesters, or three quarters of a college calculus-based physics course covering the classic fundamentals of mechanics, magnetism and electricity with a "B" average or better grade (a "C" average or better if the candidate is a physics, math or engineering curriculum major...).

serve as the final discriminators. In addition to the two technical interviews, candidates are interviewed by the Director, Naval Nuclear Propulsion Program, currently Admiral Bowman. The criteria used by the Director for selection is not published, but he does have the final determination on the fate of each candidate.

While in college, officer candidates are informed about the submarine community and life in the Navy. Naval academy midshipmen effectively serve a four-year apprenticeship before commissioning so that they acquire greater stock of navy-specific human capital and tend to assimilate more easily into the team production environment of the Navy (Mehay and Bowman, 1997a). USNA midshipmen typically are better informed about the various naval communities. NROTC midshipmen take several military classes in college; participate in various "naval" activities such as drill and sailing; and train on operational naval vessels during the summer months much like USNA midshipmen. OCS midshipmen receive no military training in college and attend a 12-week "crash course" on military life prior to becoming officers. Before a college student commits to the NUPOC program,[11] he is provided an all-expenses-paid trip to a submarine base. He tours the base and one of the submarines in port, speaking with submarine officers on board. NESEP graduates are prior enlisted sailors with significant military experience and proven capabilities. They were selected from among the ranks of enlisted sailors to become an officer.

[11] Once committing to the NUPOC program, a college student is legally bound to join the Navy. Failure to join the Navy can result in a mandatory two-year term as an enlisted sailor in the Navy.

1. Career Progression

Once commissioned, submarine officers receive one year of nuclear training and four months of general training on submarine systems and tactics. The nuclear training consists of six months of theoretical classroom training at the Navy's Nuclear Power School (NPS) in Orlando, Florida. The training covers a wide range of engineering-related subjects such as Heat Transfer, Thermodynamics, Electrical Engineering, Chemistry, and Materials Science. The training also covers reactor theory and various theoretical aspects of operating a naval nuclear reactor.

Following Nuclear Power School, officers spend six months learning how to operate a naval nuclear reactor at one of the Navy's Nuclear Prototype Training Units (NPTU). The NPTU in Charleston, South Carolina consists of two submarines that have been permanently connected to a pier. The submarines still have the original nuclear reactor and engineering spaces. Officers learn how various systems operate and spend a significant portion of their time operating the reactor and the equipment in the engineering spaces. They learn the duties associated with each of the enlisted watchstations in a submarine's engineering spaces under the instruction of qualified enlisted sailors; and they learn how to manage the entire operation as the Engineering Officer Of the Watch (EOOW), the officer responsible for the safe and proper operation of the reactor and engineering equipment. Officers will stand watch as EOOW when they serve aboard a submarine.

Finally, officers attend the Submarine Officer Basic Course (SOBC) in Groton, Connecticut. At SOBC, the officers learn about the other non-nuclear-related systems

aboard a submarine such as the navigation, diving, sonar, and weapons systems. They will train on simulators that closely resemble the real systems aboard a submarine. Upon graduation from SOBC, the officers have completed the initial training pipeline of nearly 18 months and are assigned to a submarine.

There are four levels of seniority among officers aboard a submarine. The most senior, the Commanding Officer (CO), holds the rank of Commander (CDR), grade O-5, and will have served approximately 16 to 19 years of commissioned service. The second level, the Executive Officer (XO), holds the rank of Lieutenant Commander (LCDR), grade O-4, and will have served approximately 12 to 14 years of commissioned service. The third level consists of three (four on Trident submarines)[12] Department Heads (DH) who have served approximately seven to ten years of commissioned service. The department heads are put in charge of the three departments (Engineering, Navigation, and Combat Systems) aboard a submarine. The department heads initially hold the rank of Lieutenant (LT), grade O-3, and may be promoted to LCDR during their three years as a department head. The Engineering Officer is spot-promoted to LCDR soon after reporting aboard as a department head. Finally, the least experienced officers are appropriately called "Junior Officers" (JO's) and serve as division officers in charge of one of the divisions aboard a submarine. JO's have served for two to five years of commissioned service and range in rank from Ensign (O-1) to Lieutenant (O-3). Table 2.2 summarizes the duties assigned to officers through a typical career.

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[12] There are two main types of submarines in the U.S. Navy. Fast-attack submarines (SSN), the smaller of the two, are used for a variety of missions. Trident submarines (SSBNs) carry ballistic missiles and serve primarily as part of the United States' policy of nuclear deterrence through Mutually Assured Destruction.

Table 2.2 Duty Assignments During A Typical Career

Years of Commissioned Service	Duty Assignment
16-19	CO Sea Tour
14-16	Shore
12-14	XO Sea Tour
10-12	Shore
7-10	DH Sea Tour
5-7	Shore
2-5	JO Sea Tour
0-2	Training Pipeline

Graduates of all three commissioning sources incur a commitment to serve at least five years of commissioned service. As shown in Table 2.2, officers will complete their first tour of duty aboard a submarine by this time. In this study, only 15.7 percent of submarine officers choose to leave the Navy immediately after their initial obligation is complete. However, over half of the original 3,567 submariners leave the Navy before the tenth year of service. This means that a significant number (41 percent of the original 3,567) of officers chose to complete a two-year shore tour following their JO sea tour and left the Navy after seven years of commissioned service.[13]

2. Fitness Reports

The report on the fitness of officers (FITREP or fitness report) is the major document used for periodic internal evaluation of the performance of naval officers. Fitness reports are completed annually and provide information to the Navy that is important for promotion, billet assignment, and retention. Fitness reports require the CO

[13] All figures drawn from the database used in this study.

to evaluate the officers onboard his submarine with regard to various aspects considered important to the Navy. The CO must grade such aspects as: response in stressful situations, speaking and writing ability, equipment management, watchstanding ability, tactical proficiency, and leadership. Fitness reports also provide information on performance relative to other officers at the same command, which is one of the criteria used in measuring an officer's productivity. The CO must rank each officer, and comment on his command desirability, and decide whether to recommend the officer for early promotion, regular promotion, or no promotion. (Bjerke, 1987)

Most CO's complete fitness reports with two purposes in mind: promotion potential, and command-related selection decisions. However, CO's have expressed a conflict between their obligation to identify average (or less than average) performers and their obligation to write evaluations that will not destroy an officer's chance for promotion. Consequently, most junior officers tend to be ranked in the top one percent. This tendency has increased over the years and is referred to as "grade inflation." The growing problem of grade inflation has led to doubts about the usefulness of fitness reports in selecting officers for promotion and assignment.[14] However, there are a few elements on fitness reports with sufficient variability to support the belief that fitness reports can be used as an indicator of an officer's promotability and potential for

[14] The Navy instituted a new fitness report form in 1995 with the intention of minimizing grade inflation. The new form is graded on a 5.0 scale and provides descriptive standards associated with each mark for the areas evaluated. Also, the new form prohibits verbal comparisons of officers within a competitive category. For example, a CO cannot make a comment such as "My best LT," but he can write "My best junior officer" because several grades make up the group of junior officers. However, the form provides five levels of recommendations for promotion and requires a forced distribution of the recommendations for all officers within a competitive category. Only the older fitness reports are used in this study.

command. (Bjerke, 1987) A 1989 study by Idell Neumann of the Navy Personnel Research and Development Center (NPRDC), San Diego, found sufficient variability in the element "recommended for accelerated promotion" (RAP) to be used as a performance index. Neumann's study is discussed further in the following section of this chapter.

3. Promotion to LCDR (O-4)

Selection boards, manned by senior officers within each community, decide who will promote to the next senior grade. Promotion to lieutenant junior grade (LTjg) and lieutenant (LT) is nearly automatic with less than five percent of officers failing to promote. However, promotion to LCDR presents the first significant hurdle to a submarine officer's career. By the time of the O-4 board, six out of ten submariners will have left the Navy, mostly voluntarily. Of the remaining 40 percent, approximately 80 percent successfully promote to LCDR.

An officer may receive three opportunities (be reviewed by three selection boards) for promotion to LCDR. The board convenes annually and officers typically are considered for promotion during their ninth through eleventh year of commissioned service.

C. RELEVANT PAST STUDIES

Many studies have validated the theory that education, as an investment in human capital, leads to positive returns. Individuals investing in more education (to a point) have

earned more and enjoyed greater job satisfaction. There is a growing body of research that has analyzed the relationships between college characteristics and worker productivity. However, most of these studies lack direct measures of worker productivity and instead use hourly pay or annual earnings as an estimate of worker productivity. These studies have focused on the effect of college selectivity; testing the assumption that attending a more selective, and presumably higher quality, institution will lead to higher earnings. Additionally, the studies have analyzed the effects of college major and grade point average, testing the impact of cognitive skills and the combined effect of college quality and student performance on earnings. (Mehay and Bowman, 1997b)

Other studies have attempted to more directly measure the effects of college characteristics on earnings by analyzing employees in a single firm. A well-known study by Wise (1975), investigated the effects of both personal and college characteristics on worker productivity at a large manufacturing firm. He used growth in annual earnings and frequency of promotions as proxies for productivity. Wise assumed that the probability of promotion from one level to the next was evidence of relative job performance and he regarded promotion as a more direct measure of performance than earnings. He stated that it is wrong to assume that earnings match individual performance because salaries are tied to positions within an organization, rather than to the performance of the individual filling the position at any one time. Therefore, he reasoned that the differences between grade levels and rate of promotion may be a better proxy for job performance than salary.

The study analyzed white males hired at a single manufacturing firm between 1946 and 1964 who were still employed by the firm in 1968 and who were not more than 30

years old when hired. He included both technical and non-technical positions. A random stratified sample of 1,300 workers was selected for analysis from approximately 6,800 persons. Information on the workers included selectivity of college attended, grade point average, college major, and employment history.

Wise found that the relationship between college quality and grades, and worker performance was "not only statistically significant but...quantitatively important." He also observed that individuals from the most selective schools with high grades have an estimated rate of salary increase that is twice that of graduates from the least selective schools with low grades.

Wise's study has been criticized because the sample of workers analyzed is not representative of the nation's overall work force population and because he failed to describe the structure of the internal labor market. The study includes only white males and it excludes workers whom, for whatever reason, were no longer employed with their initial hiring employer. Therefore, omitted from the analysis are those who chose to leave voluntarily for better jobs and/or higher pay and those involuntarily released by the firm. Wise's failure to describe the structure of the internal labor market is serious because his study is based on promotion within the firm. Without knowledge of the firm's career ladders, there is no way to determine the pool of personnel eligible and qualified for promotion, thus promotion rates are likely to be measured incorrectly. (Mehay and Bowman, 1997b)

Edward Lazear (1977) questioned Wise's conclusion that college education contributes to productive ability, calling it unwarranted. Lazear felt the results of Wise's

study could support the theory that education serves as a screen as well as the conclusion that it improves job productivity. Screening theory states that education does not improve an individual's productivity, but rather serves as a criterion which employers use to sort individuals. According to screening theory, the output enhancement of grades is solely through an informational role of differentiating individual ability levels to prospective employers.

This thesis also utilizes a population that is not representative of the nation's workforce population, but it is not the objective of this study to determine the effects of academic background for the average American worker. However, the second criticism is corrected in this study. This study will also use promotion probability as a measure of productivity, but in the context of the well-defined internal labor market and career path of submarine officers. A detailed description of the submarine community's internal labor market and the performance measures used in this study is provided in section B of this chapter.

More recent studies have used selected cohorts from the National Longitudinal Survey (NLS) that appears to be more representative of the nation's work force population. The NLS database contains information on randomly selected high school graduates from across the nation.

James et al. (1989) used the 1972 cohort from the NLS data (NLS-72) to analyze the impacts of college characteristics on post-college earnings. NLS-72 was initially composed of 21,000 randomly selected high school graduates, but the study restricted the analysis to 1,241 male survey respondents, including only those who actually graduated

from college and were employed in 1985. These restrictions made the statistical analysis less complex, but causes the analyzed data to be less representative of the general workforce. (Mehay and Bowman, 1997b)

The NLS-72 data was combined with information from the Higher Education General Information Survey (HEGIS) and the Postsecondary Education Transcript Study (PETS). The authors sought to identify those college characteristics that create an "aspect of quality." In the sample used, 519 colleges and universities were represented. The HEGIS data provided information about the 519 institutions and the PETS data provided information from the college transcripts of the individuals in the study.

The study analyzed the impacts of college characteristics on post-college earnings, controlling for student background, higher educational experience, and labor market variables. College selectivity (or college quality) was estimated by the average Scholastic Aptitude Test (SAT) score of entering freshmen. Other institutional characteristics were controlled, such as the percentage of part-time students, the percentage of graduating students with liberal arts majors, and the percentage of graduate students.

The study found positive impacts of college selectivity and grade point average on annual earnings. Also, the study found that undergraduate major had an impact too. Engineering and business majors had a strong positive effect (30 percent and 10 percent, respectively); education majors had a strong negative effect (15 percent); and the effects of humanities, social sciences, mathematics, and biology/physical sciences majors were statistically insignificant. A 100-point increase in the institution's average SAT score, the study's proxy for college selectivity, resulted in a three percent increase in annual

earnings. Also, grade point average (GPA) had a positive effect on annual earnings, even when occupation was controlled. A one-letter grade increase in GPA, C to B or B to A, resulted in a nine percent increase in annual earnings. The authors surmised that "while GPA indicates, in part, that students have acquired specific knowledge, we think of it additionally as a proxy for general human capital characteristics such as ability and habits of discipline and perseverance."

The authors concluded that choice of major and grades have a much stronger impact than the choice of institution on future earnings. They quipped, "While sending your child to Harvard appears to be a good investment, sending him to your local state university to major in Engineering, to take lots of math, and preferably to attain a high GPA, is an even better investment." The model development used in this thesis is similar to that used by James with the exception that the Barron's Index of College Selectivity is used as a measure of college selectivity/quality. Undergraduate majors are grouped into similar categories and grades are included in the model.

Bowman (1990), a professor of Economics at the U.S. Naval Academy, asked the question "Do Engineers Make Better Naval Officers?" His study tested the commonly held belief in the Navy that engineering majors provide the best preparation for officers to handle the modern technology utilized in today's naval vessels. Admiral Rickover, the father of the nuclear navy, was especially outspoken concerning the belief that a technically trained undergraduate will make a better officer, leading to the moniker "Rickover hypothesis."

Bowman's study examined the Rickover hypothesis for a subset of USNA graduates from 1976 through 1980 who entered the surface and submarine warfare communities.[15] He noted that "these communities were selected because they represent the most likely communities in which technical subjects may be applied in the work environment aboard sophisticated warships." The sample consisted of 1,560 graduates for whom all information used in the study was available.[16] The database used in this thesis is an updated version of the database used in Bowman's study.[17]

The study used two measures of performance. The first measure was based on an officer's performance while acting as a division head on his first sea duty, approximately his fourth year of commissioned service. The officer's performance was judged to be "superior" if the officer was recommended for early promotion and ranked in the top one percent category for both "command desirability" and in the "overall summary" evaluation. Superior performance was achieved by 44.8 percent of officers ranging from 40 percent for nuclear-trained officers to 49 percent for those serving in the conventional surface navy. The second measure was retention. It measured the probability that an officer would remain in the service at least six months beyond his initial period of obligation. Approximately 20 percent of the officers left the Navy immediately following

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[15] At USNA, all midshipmen receive a Bachelor of Science degree regardless of their undergraduate major. Every student, even humanities majors are required to take an assortment of engineering and science classes that meet the requirements of a Bachelor of Science degree. Additionally, the academy's administration limits the number of midshipmen in non-engineering majors. It requires that a certain percentage of midshipmen select engineering majors. Also, no more than 20 percent of all midshipmen were permitted to select humanities/social science majors during the period covered in Bowman's study.

[16] 198 male graduates selecting the submarine or surface communities were excluded because of death, involuntary separation, or missing information.

[17] See Chapter III, DATA AND METHODOLOGY, for a description of the database used.

their term of obligated service, 16.4 percent in the conventional surface community and 25 percent in the nuclear communities.

The study controlled for officers' personal characteristics and fleet experience, including such factors as race, marital status, ship type, and nature of the fitness report used to develop the performance measure. Bowman found that many of the control factors were significantly related to officer performance and retention. Ship type was significant in a few cases. Service on attack submarines (SSNs), relative to SSBNs, increased the likelihood of retention by 13.9 percent. Variables that controlled for the environment in which the fitness report was written were either insignificant or had minimal effect. Finally, race and marital status were found to have a significant effect on performance and retention. In the conventional surface navy: racial minorities were from 19.2 percent to 25.6 percent less likely than whites to achieve "superior" status; blacks were 23 percent more likely to stay beyond their initial period of obligation; married officers were 15 percent less likely to retain. In the nuclear navy, married officers were far less likely than single officers to remain beyond their initial obligation; those with children were 27.8 percent less likely to remain and those without children were 35.6 percent less likely to remain.

Bowman attempted to test/control for self-selectivity bias through the use of the Heckman procedure.[18] The Heckman procedure accounts for unobserved factors retained from the selection equation (in this case, selection of warfare community) through a new

[18] See Heckman, James J., 1979. "Sample Selection Bias as a Specification Error," *Econometrica*, 47(1), January: 153-161.

independent variable that is added to the performance equation. This variable, LAMBDA, was found to statistically insignificant, meaning that selectivity bias was not detected. Despite evidence from the selection model that graduates with technical majors and higher grades are more likely to choose and be selected by the nuclear navy, Bowman attributed LAMBDA's insignificance to the lack of correlation between the error structure of the two equations. As stated before, this thesis will not attempt to account for selection bias. It is desired that the effects of selection bias be included with the effects of the academic variables.

Finally, Bowman found that few academic factors were significantly related to junior officer performance and retention. Controlling for the factors listed above, he found that academic major had little, if any, effect on retention or performance. Two exceptions were noted in the conventional surface navy. First, management/economics majors (relative to an engineering major) were 24.1 percent more likely to attain "superior" status. Second, general engineering/sciences majors (relative to an engineering major) were 8.3 percent more likely to stay beyond the initial obligation. Similarly, insignificant relationships were found between grades and performance/retention with one exception. A one-point differential in grades for an engineering major reduced the probability of staying beyond the initial obligation by 13.1 percent in the nuclear navy.

Bowman's findings refuted the Rickover hypothesis that technical education provides the best preparation for naval officers. His results were surprising considering the emphasis placed on technical background by the nuclear navy. Several weaknesses should be noted though. The study included only officers who graduated from the Naval

Academy. All USNA midshipmen receive significant instruction in technical studies. In fact, the required curriculum includes sufficient engineering and science courses for every midshipman to graduate with a Bachelor of Science regardless of undergraduate major. This thesis includes all officers who entered the submarine community regardless of commissioning source.

Also, the criteria used for evaluating "superior" performance is suspect. Bowman selected a single fitness report that indicated "frequent" contact with the reporting senior officer, that evaluated the officer in relation to his peers (i.e., periodic/annual, or on the occasion of detachment of a reporting senior officer), and was the last report as a division officer. This one fitness report was critical, however, as it was the last competitive report received by the officer as a division officer. As described above, a "superior" performer was defined as one who was recommended for early promotion, and ranked in the top one percent category both for "command desirability" and in the "overall summary" evaluation on the selected fitness report. The measure is suspect because only one fitness report was used.

Being recommended for accelerated promotion appears to be the most discriminating performance measure available. A study conducted by Idell Neumann (1989) of the Navy Personnel Research and Development Center (NPRDC), San Diego, developed a performance index derived from officer fitness reports. The data for the development of the performance index consisted of all Naval Academy graduates from 1979 through 1982 in the surface, submarine, and pilot communities. Each of the officers had at least four years of commissioned service and the associated fitness reports.

Neumann's objective was to identify which information on a fitness report could provide a selection board suitable indication of an officer's promotability or worth to the Navy. She found that "recommended for accelerated promotion" (RAP'd) was the only element with sufficient variability to be used as a performance index. This thesis uses the likelihood of an officer being RAP'd on greater than 75 percent of his O-3 fitness reports as a measure of performance.

More recently, Mehay and Bowman (1997b) analyzed the impact of college quality and academic performance on the job performance of naval officers. Their study utilized the same database used in this thesis. The database consists of 24,672 operational (in one of the warfare communities) officers and 9,356 similar staff officers who graduated from over 563 private and public colleges and universities between 1977 and 1985. Information is available through the first ten years of each officer's career or until separation from the Navy.

Their results corroborated those of previous studies of civilian workers, which found that academic achievement and college quality had a positive impact on earnings. The study found that graduates of elite colleges are more productive in the work place, even after controlling for grades and majors. Also, better grades were found to improve the probability of promoting to LCDR. However, their results contradicted the findings of past studies of civilian workers that technical majors lead to higher earnings. They found that technical degrees negatively affected on-the-job performance and that no major had a significant effect on promotion to LCDR.

Michael Nakada and James Boyle (1996) analyzed the effect of the Nuclear Officer Incentive Pay (NOIP) program on nuclear officer retention beyond minimum service requirement (MSR). While an economic model, not the focus of this study, their conclusions made statements, which are relevant to the research in this study. They found that accession source was significant in retention decisions. Specifically, USNA graduates had the highest retention rates beyond MSR. They also determined that as the number of household dependents increased, the likelihood of retention increased. Again in 1996, Nakada led another study to expand his research conducted with Boyle (Nakada, et al., 1996). This second study quantified the effects of NOIP for individual years beyond MSR and found effects that were consistent with the earlier research. By using an Annual Cost Of Leaving (ACOL) model, Nakada quantified retention at annual increments and not just specific transition points in a military career. Both studies found that bonuses had a positive effect on retention. "For both communities, the retention elasticities with respect to the NOIP retention bonus program were small, but significant indicating that 'pay does matter.'"

This thesis extends research on the returns to investments in education and more specifically provides nuclear navy recruiters with valuable information. Although many studies, including studies of naval officers, have analyzed the returns to a college education, none have been conducted with the objective of providing information that will aid recruitment efforts. This study identifies what type college academic background signifies an individual who is likely to perform well as a submarine officer and is likely to

remain in the submarine community. NUPOC recruiters can use this information to target college students who are likely to perform well in the submarine community.

III. DATA AND METHODOLOGY

This chapter discusses the database and how it is used to develop the explanatory variables, which describe undergraduate academic experience and performance outcomes introduced in Chapter I. A discussion of the statistical methodologies used in the study concludes the chapter.

A. DESCRIPTION OF DATABASE USED IN THIS STUDY

The database derived in this study comes from one that includes nearly all of the college graduates who were commissioned as naval officers from 1977 to 1985 and follows them through their first ten years in the Navy. A negligible minority of the population, who left the Navy involuntarily or for medical reasons during the first two grades (Ensign and LTjg) while serving their initial obligation, is missing from the database. The database approximates a longitudinal cohort file in that it builds prior employment histories from retrospective data collected for all officers appearing at the O-3 (3 YCS) and O-4 (10 YCS) promotion boards, as well as those who leave the Navy up through the O-4 board. Any officer leaving because of medical reasons or death during this period is purposely excluded. The resulting basic data includes 24,672 operational officers who are automatically considered for promotion to LT during their third year of service.

This database is derived from three existing administrative data files maintained on every U.S. Navy officer by the Naval Bureau of Personnel, Washington, D.C. The first

data file utilizes a wealth of information contained in the Navy History Promotion Files, which is a combination of data elements taken from Officer Data Cards and promotion outcomes. The file contains over 600 data elements. A second file, the Officer Loss file, is used to ascertain the timing and reason why any officer in the data set left active duty. The last file is composed of summary data from fitness reports for nearly ninety percent of all officers in the data set. Naval officers are evaluated at least once a year on a fitness report. Additional fitness reports are completed when an officer or the reporting senior officer completes duty at the command. The resulting database, used in this study, contains detailed information concerning demographics, pre-commissioning characteristics, and work history for the first ten years of an officer's career.

Because the objective of this study is to analyze the impact of academic background on submariner performance and retention, the officer community designator is used to restrict the sample to the submarine community. To ensure there are no missing values for any variables, only officers with complete data on all elements are included in the analysis.[19] Table 3.1 lists the initial mean values of important explanatory variables used in the study (e.g., prior enlisted experience, ethnicity, commissioning source, college selectivity, undergraduate major, and college grades). The table provides a comparison of the mean values for officers included in the study to those excluded due to missing values.

[19] This process results in 959 of 4526 officers commissioned as a submariner (21 percent) being excluded from the study. About four-fifths of the exclusions are due to missing grades, the other one-fifth are missing information on the officer's undergraduate major.

Table 3.1 Comparison of Means for Submariners Included in the Study to Those Excluded (Initial Population)

Explanatory Variable	Submariners included in model (N=3567)	Submariners excluded due to missing values (N=959)
Demographics		
>2 years enlisted experience	.087	.093
Minority	.028	.039
Undergraduate Major		
Biology/Physical Sciences	.213	.187
Math/Computer Science	.094	.089
Engineering	.607	.669
Social Sciences	.033	.020
Management/Economics	.033	.023
Humanities	.021	.013
Commissioning Source		
USNA	.427	.179
NROTC	.266	.284
OCS	.278	.527
NESEP	.030	.010
College Quality		
For ROTC Graduates:		
High Selectivity	.414	.463
Medium Selectivity	.292	.390
Low Selectivity	.294	.146
For OCS Graduates:		
High Selectivity	.159	.207
Medium Selectivity	.394	.417
Low Selectivity	.447	.376
Academic Achievement		
GPA (top three categories)		
5: 3.60-4.00	.162	.191
4: 3.20-3.59	.321	.369
3: 2.60-3.19	.454	.401
Dependent Variables		
"Graduate"	.862	.895
"Performance"	.564	.546
"Retention"	.409	.186
"Promotion" [20]	.351	.152

[20] These numbers represent the percentage of all submariners included in this study that promote to LCDR. Promotion rate is the percentage of those who stay until the O-4 board that promote to LCDR. Promotion rate of those who stayed until the O-4 board equals PROMOTE / RETAIN. Therefore, for those included in the study, 80.9 percent (.351/.409) promoted to LCDR, and for those excluded, 81.7 percent (.152/.186) promoted.

In general, the composition of the excluded subset is fairly similar to the population in the analysis with the exception of commissioning source. USNA graduates represent 42.7% of the officers in this study, but they make up only 17.9% of the officers in the excluded subset. Also, OCS graduates represent only 27.8 percent of the officers in the study, but are 52.7 percent of the officers in the excluded subset. NROTC and NESEP graduates are evenly distributed between the two subsets. With the exception of commissioning source, there appears to be no serious representation problems in using the data file, particularly for the principle variables of interest, college quality, college major and college grades. It is the objective of this study to examine what type of student from the various commissioning sources will perform well as a submarine officer, not to determine which commissioning source provides the best preparation. Commissioning source is mainly included in the study as an important control variable. Also, the distributions of the dependent variables are similar with the exception of "Retention" and "Promotion." As explained in footnote 20, the promotion rates are similar, but the retention rate of those excluded is much lower than those included in this study. As Table 3.1 indicates, there are no large differences in background characteristics, but those who are less likely to remain in the Navy are more likely to be excluded from this study.

Only officers who were commissioned as a submariner are included in the analysis. Although only 315 officers (8.8 percent), transferred into the submarine community after commissioning, the intent of this study is to analyze the effect of academic background on just the officers who were initially recruited to be submarine officers, testing the submarine force's initial screening policies.

Measuring the likelihood of completing the nuclear training pipeline is based on the assumption that an officer who transferred out of the submarine community between the commissioning date and the date of the O-3 board, at approximately three years-of-service, failed to complete the nuclear training pipeline. This assumption should hold true for most of the officers who transferred to other communities.

The model that measures an officer's performance as a LT (O-3) suffers from additional missing values. The fitness reports selected for inclusion in the analysis are restricted to those that indicate "periodic" or "detachment of reporting senior" in the block for occasion, "regular" in the block for type of report, and "close" in the block for the basis of the reporting senior's observation of the officer. These restrictions ensure that officers in the sample were evaluated against all their peers in the command, and that they worked closely with the reporting senior officer, which reveals a more accurate picture of the officer's true performance.[21] An analysis of the observations with missing fitness report information indicates that there is little or no systematic relationship with any of the explanatory variables. There is, however, a significant relationship with the other dependent variables. Table 3.2 provides a comparison of mean values for the 2599 officers included in the O-3 performance model to the 477 officers excluded due to missing fitness report information.

Only 8.8 percent of officers with missing O-3 fitness report information remained until their O-4 board, compared to 50.4 percent of officers with information. It is likely

[21] This process results in 477 of 3076 submarine LT's (15.5 percent) being excluded from the study.

Table 3.2 Comparison of Means for Submariners Included in the Performance Model to those Excluded from this Model (provided due to additional exclusions from those displayed in Table 3.1)

Explanatory Variable	Submariners included in model (N=2599)	Submariners excluded due to missing values (N=477)
Demographics		
>2 years enlisted experience	.095	.065
Minority	.026	.025
Undergraduate Major		
Biology/Physical Sciences	.201	.254
Math/Computer Science	.094	.094
Engineering	.623	.597
Social Sciences	.029	.023
Management/Economics	.030	.014
Humanities	.023	.017
Commissioning Source		
USNA	.426	.298
NROTC	.256	.312
OCS	.287	.359
NESEP	.031	.031
College Quality		
For ROTC Graduates:		
High Selectivity	.400	.423
Medium Selectivity	.307	.255
Low Selectivity	.293	.322
For OCS Graduates:		
High Selectivity	.165	.164
Medium Selectivity	.385	.444
Low Selectivity	.450	.392
Academic Achievement		
GPA (top three categories)		
5: 3.60-4.00	.174	.153
4: 3.20-3.59	.323	.365
3: 2.60-3.19	.445	.434
Dependent Variables		
"Graduate"	1.00	1.00
"Performance"	.564	data missing
"Retention"	.504	.088
"Promotion"[22]	.415	.036

[22] Promotion rate of those who stayed until the O-4 board equals PROMOTE / RETAIN. Therefore, for those included in the model, 82.3 percent (.415/.504) promoted to LCDR, and for those excluded, 40.9 percent (.036/.088) promoted. Because promotion decisions are based partly upon fitness report evaluations, officers with no valid O-3 fitness reports are less likely to be selected for promotion.

that for many of those excluded, their O-3 fitness report information is missing simply because they did not stay until the O-4 board. Many of those who left the Navy after their initial service obligation did not receive a "valid" O-3 fitness report. As discussed above, only "valid" fitness reports (those on which the officer was compared against other officers and had close contact with the reporting senior) are included in this study. Of those who stayed until their O-4 board, 40.9 percent of those without O-3 fitness report information promoted to LCDR, compared to 82.3 percent of those with information. Due to a low correlation between missing O-3 fitness report information and the explanatory variables, and to prevent overly small sample sizes, no officers are excluded from the other models based on missing O-3 fitness report information.

The criterion for Y=1 in the "Performance" model requires that an officer be recommended for accelerated promotion (RAP'd) on greater than 75 percent of his O-3 fitness reports. The officers included in this model received an average of 4.3 valid O-3 fitness reports, and therefore, in order to meet the 75 percent criterion, an officer must have been RAP'd on three out of the four valid reports. 75 percent is selected as the threshold for this model because approximately half of the officers meet this criterion.

Figure 3.1 provides a graphic representation of the major points of career progression in the submarine community and a summary of the data used in this study. The database used in this study includes 4,526 officers who were commissioned into the submarine community from 1977 to 1985. Of those, 3,567 are included in this study. 491 (14 percent) failed to complete the nuclear training pipeline and transferred to other communities. Of those who successfully completed the training pipeline, 1818 (59

percent) left the Navy prior to their O-4 board. And, of the 1,258 who remained until the O-4 board, 1,031 (82 percent) successfully promoted to LCDR.

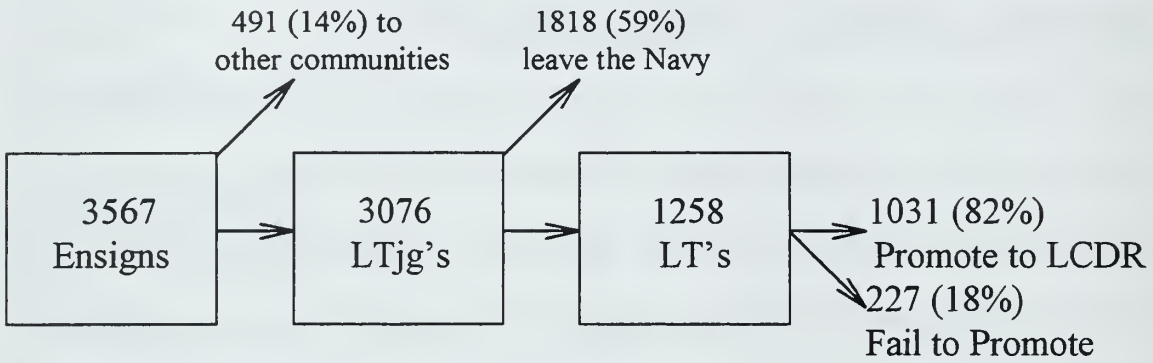

Figure 3.1 Career Progression in the Submarine Community

B. METHODOLOGY

This study utilizes four multivariate models to analyze various aspects of the submarine community's career progression. Because each model has a dichotomous dependent variable, a nonlinear maximum-likelihood probit procedure is used. The probit procedure constrains the predicted values to the measured unit interval of zero to one and calculates the effect of the explanatory variables on the probability of the selected outcome. The probit uses the normal Cumulative Distribution Function (CDF) in estimating the model. Assume we let Y=1 if the criteria for the dependent variable are met, and Y=0 if the criteria are not met. There is an unobservable critical threshold level index, call it I_i^*, such that if I_i, the combined value of an individual's explanatory variables, exceeds I_i^*, the officer will meet the criteria for the dependent variable, otherwise he will not. For a more complete discussion of the probit function, refer to any basic econometrics textbook.

The probit models measure the likelihood of: (1) completing the nuclear training pipeline (Graduate); (2) being RAP'd on greater than 75 percent of one's O-3 fitness reports (Performance); (3) remaining until the O-4 board for those who successfully complete the training pipeline (Retention); and (4) promoting to LCDR for those remaining until the O-4 board (Promote). The analyses are performed on three groupings of the population: (1) on the entire submariner population, (2) just OCS graduates, and (3) on USNA and NROTC graduates in order to determine whether the effects of academic background are different for OCS graduates than for USNA and NROTC graduates. The expectation is that graduates from scholarship programs (USNA and NNROTC), who made a commitment to the Navy upon entering college, are characteristically different from those who were recruited (OCS) into the Navy. Table 3.3 provides a complete description of the dependent variables used in the models.

Table 3.3. Description of Dependent Variables

Variable	Description
GRADUATE	= 1 if officer completed the nuclear training pipeline. = 0 otherwise.
PERFORMANCE	= 1 if officer was recommended for accelerated promotion on greater than 75 percent of his O-3 fitness reports (of those who completed the training pipeline).[23] = 0 otherwise.
RETENTION	= 1 if the officer remained in the Navy and the submarine community until the O-4 board (of those who completed the training pipeline). = 0 otherwise.
PROMOTE	= 1 if the officer promoted to LCDR (of those who remain until the O-4 board). = 0 otherwise.

[23] The officers in this study received an average of 4.32 valid O-3 fitness reports. Therefore, on average, an officer may only fail to be RAP'd on one O-3 fitness report in order to meet the criteria for "superior" performance.

Figure 3.2 displays the percentage of officers in each model and population subset who meet the criteria for Y=1 for each dependent variable.

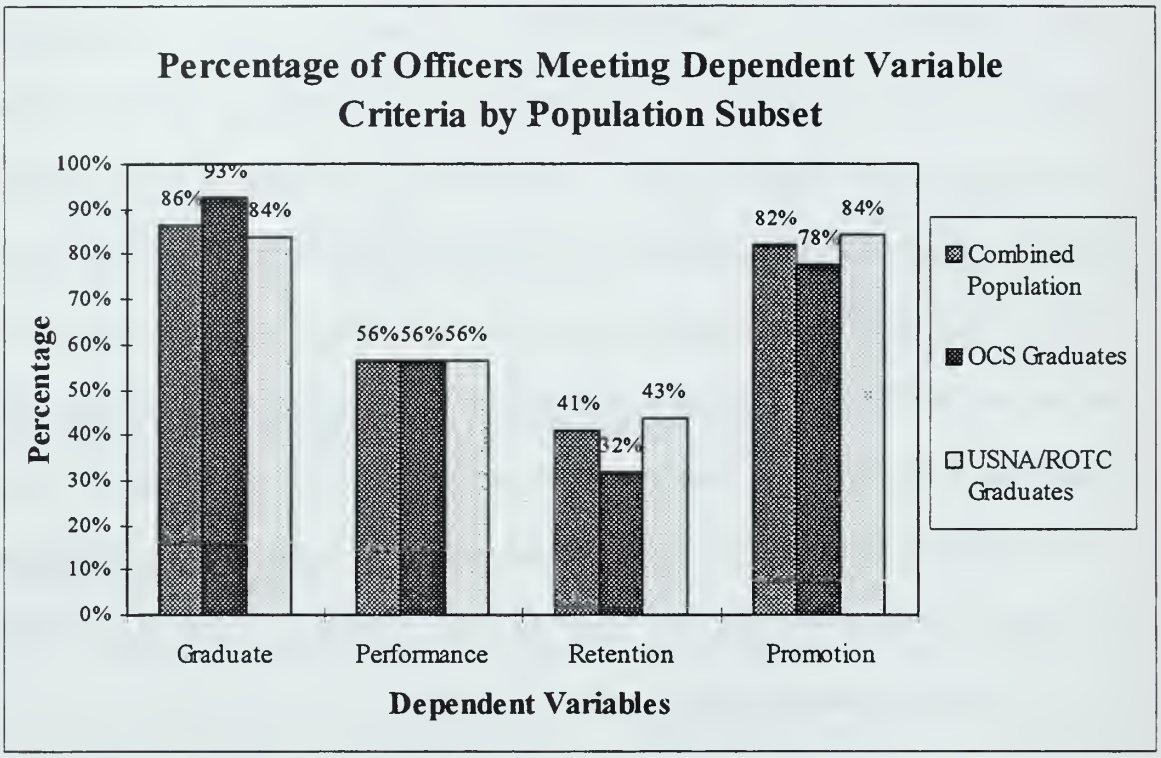

Figure 3.2 The Percentage of Officers Meeting Dependent Variable Criteria (for Y=1) by Population Subset

The independent variables of interest are commissioning source, college quality, undergraduate major, and college grades. Additional control variables are included to control for prior enlisted experience, ethnicity, and the year of commissioning. The intention of the commissioning year variable is to control for varying environment in the submarine community with respect to fitness reports, retention, and promotion to LCDR. Commissioning year is calculated by subtracting four years form the fiscal year of the officer's O-3 board. This calculation is necessary due to unreliable information for commissioning year in the database. Ethnicity is controlled through the variable

"Minority" which equals one if the officer is a minority (on the basis of race), or zero if the officer is Caucasian. "Greater than two years of enlisted experience" indicates whether or not an officer has greater than two years of prior enlisted experience.

Undergraduate majors are grouped into six categories: Biology and Physical Sciences, Mathematics and Computer Science, Engineering, Social Sciences, Management and Economics, and the Humanities. Grades are estimated through the use of the military's Academic Profile Code 1 (APC1). APC1 ranges from zero for the highest grade point averages to five for the lowest averages. In this study, grades are estimated through the variable GPA = (5-APC1), so that five is assigned to the highest grades category and zero to the lowest.

The military uses Academic Profile Codes to aid in screening officers for selection to postgraduate education programs. APC2, the Math Qualification Code, measures the quantity and quality of math education received by an officer and APC3, the Technical Qualification Code, measures the quantity and quality of education in engineering and physics received by the officer. APC2 ranges from zero for the highest measure of math education to six for the lowest. APC3 ranges from zero to five. In this study, the variables "Math Proficiency" and "Technical Proficiency" are used. "Math Proficiency" = (6-APC2) and "Technical Proficiency" = (5-APC3). They are included in the study to capture the scope of an individual's technical education as an undergraduate.[24]

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[24] As expected, "Math Proficiency" and "Technical Proficiency" correlate with an officer's undergraduate major. However, the level of correlation is not as much as one might expect. The models are analyzed three ways: (1) with both Undergraduate Major, and "Math Proficiency" and "Technical Proficiency" included, (2) Undergraduate Major only, and (3) "Math Proficiency" and "Technical Proficiency" only. The models with all three variables provided decidedly better estimates of the probability of the criteria for the dependent variable being met.

Table 3.4 Description of Independent Variables

Variable	Description
Undergraduate Major	
Biology/Physical Sciences	= 1 if officer is a biology, physical sciences, or related major
Math/Computer Science	= 1 if officer is a math, computer science, or related major
Engineering	= 1 if officer is an engineering major
Social Sciences	= 1 if officer is a social sciences major
Management/Economics	= 1 if officer is a management, economics, or related major
Humanities	= 1 if officer is a humanities major
Academic Achievement	
GPA	*Undergraduate grade point average where:*
0	0.00-1.89
1	1.90-2.19
2	2.20-2.59
3	2.60-3.19
4	3.20-3.59
5	3.60-4.00
Math Proficiency	*Measure of quantity and quality of math education:*
0	no math with C grade
1	at least one pre-calculus course with C grade
2	at least two pre-calculus courses with B+ average or better
3	one calculus course with C grade or better
4	two or more calculus courses with C+ average
5	two or more calculus courses with B+ average
6	Significant post-calculus math with at least B average
Technical Proficiency	*Measure of quantity and quality of physics and engineering courses:*
0	no courses in lower division calculus-based physics
1	at least one course in lower division calculus-based physics with C grade
2	Complete sequence (lower division calculus-based physics) taken with C+ average
3	Complete sequence (lower division calculus-based physics) taken with B+ average
4	Upper division courses in engineering/physical science major with C+ average
5	Upper division courses in engineering/physical science major with B+ average

Commissioning Source interacted with College Quality	
USNA	=1 if commissioned through the U.S. Naval Academy = 0 otherwise
NROTC high selectivity	= 1 if commissioned through NROTC at school in Barron's Categories 1 or 2 = 0 otherwise
NROTC medium selectivity	= 1 if commissioned through NROTC at school in Barron's Category 3 = 0 otherwise
NROTC low selectivity	= 1 if commissioned through NROTC at school in Barron's Categories 4 through 7 = 0 otherwise
OCS high selectivity	= 1 if commissioned through OCS and attended an undergraduate school in Barron's Categories 1 or 2 = 0 otherwise
OCS medium selectivity	= 1 if commissioned through OCS and attended an undergraduate school in Barron's Category 3 = 0 otherwise
OCS low selectivity	= 1 if commissioned through OCS and attended an undergraduate school in Barron's Categories 4 through 7 = 0 otherwise
NESEP	= 1 if commissioned through NESEP = 0 otherwise
Commissioning Year	
FY77	= 1 if commissioned in fiscal year 1977
FY78	= 1 if commissioned in fiscal year 1978
FY79	= 1 if commissioned in fiscal year 1979
FY80	= 1 if commissioned in fiscal year 1980
FY81	= 1 if commissioned in fiscal year 1981
FY82	= 1 if commissioned in fiscal year 1982
FY83	= 1 if commissioned in fiscal year 1983
FY84	= 1 if commissioned in fiscal year 1984
FY85	= 1 if commissioned in fiscal year 1985
Demographics	
>2 years enlisted experience	= 1 if officer has two or more years of prior enlisted experience = 0 otherwise
Minority	= 1 if officer is a racial minority = 0 if Caucasian

College quality is estimated through the use of Barron's Profiles of American Colleges, which rates each college in the nation on an index of selectivity. Barron's index lists seven categories of selectivity with Category 1 meaning the most selective and 6 indicating the least selective. Category 7 consists of schools such as Art and Divinity Schools, which are not classified on the basis of selectivity. This study divides the schools into three categories called High, Medium, and Low. High refers to a highly selective school (Barron's Categories 1 or 2) and consists of schools such as Harvard or UC Berkeley; Medium (Barron's Category 3) generally consists of large state universities; and Low (Barron's Categories 4 to 7) refers to schools with open admissions or relatively low entrance standards. College quality and commissioning source (NROTC and OCS) are combined to capture interactions between the two measures.

Table 3.5 lists the expected effects of important explanatory variables. It i expected that engineering majors will fare the best on performance measures due to greater specific training (technical training) that is useful to the submarine force. It is uncertain what effect major will have on "Retention." Two opposing effects exist. Typically engineering majors earn the most money in the civilian workplace and therefore officers with engineering majors may choose to leave the Navy due to greater civilian employment opportunities. However, engineering majors may enjoy greater job satisfaction in the submarine force due to greater specific training and therefore will choose to remain in the Navy.

It is expected that officers with better grades will perform better on the measures of performance due to greater capability, but will be more likely to leave the Navy due to

greater civilian employment opportunities. Higher quality schools will have the same effect.

USNA is expected to have a positive effect on both performance and retention due to greater amounts of Navy-specific training and a displayed propensity towards a career in the Navy. Because NESEP graduates are mostly prior enlisted members, it is expected that they will perform better and be more likely to remain in the Navy than USNA graduates. They have been hand-picked from the enlisted ranks to become an officer after displaying traits considered important towards success as an officer. Also, they are closer to reaching 20 years of service (point of voluntary retirement with benefits) and therefore are more likely to remain in the Navy.

Table 3.5 Expected Effects of Selected Explanatory Variables

Variable	Expected Effect on Performance Measures	Expected Effect on Retention
Undergraduate Major		
(with respect to Engineering)		
Biology/Physical Sciences	negative	Uncertain
Math/Computer Science	negative	Uncertain
Social Sciences	negative	Uncertain
Management/Economics	negative	Uncertain
Humanities	negative	Uncertain
Academic Achievement		
GPA	positive	Negative
Commissioning Source		
(with respect to USNA)		
NROTC	negative	Negative
OCS	negative	Negative
NESEP	positive	Positive
College Quality		
(WRT high selectivity)		
Medium selectivity	negative	Positive
Low selectivity	negative	Positive

IV. RESULTS

This study finds that all of the explanatory variables of interest--undergraduate major, grades, commissioning source, and college quality--affect submariner performance and retention. This chapter discusses the results of the multivariate models, presenting the marginal effect[25] of each explanatory variable on each of the dependent variables. Complete results, including the probit estimate and chi-square value for each variable are presented in Appendix A. Marginal effects are only calculated for variables that are significant at the .10 level or better. Blank values in this chapter's tables indicate that the variable's effect on that particular dependent variable is insignificant, but the variable is still included in the model.

The results are organized according to "groups" of explanatory variables. The effects for a type of explanatory variable (e.g., undergraduate major) are presented first for the combined population, then separately for OCS graduates, and for USNA and NROTC graduates combined. These sub-samples are created to determine whether the effects of academic background variables are different for OCS graduates than for USNA and NROTC graduates. In this chapter, the term "scholarship graduates" refers to USNA and NROTC graduates. USNA and NROTC graduates enter college with a full scholarship by the Navy contingent upon commitment to serve in the Navy for five years following graduation.

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[25] Calculated by multiplying the estimated coefficient by the density of the standard normal distribution function corresponding to the particular probability level, as given by the cumulative normal distribution function for which the change is being evaluated. (Gunderson, 1980)

Each table lists the effects for a group of explanatory variables on all four dependent variables. Additionally, graphs display the effect of grades on the dependent variables for each of the three analyses. Explanatory variables are listed in order of importance to this study, starting with undergraduate major, followed by grades, commissioning source interacted with college quality, and demographic characteristics. Marginal effects are not calculated for commissioning year control variables, but their level-of-significance and probit estimates are listed in Appendix A. Also listed in Appendix A are the mean values of the various explanatory variables used to calculate the marginal effects. Appendix B provides a more complete listing of the distribution of officers among the various categories including the actual number and percentage of officers in each category. Given the heavily skewed distribution towards higher grades and technical majors (particularly engineering majors), it is important to consider the number of officers in each category when analyzing the results of this study.

A. UNDERGRADUATE MAJOR

Table 4.1 shows that undergraduate major significantly affects the likelihood of remaining in the Navy and of completing the nuclear training pipeline. However, it has little effect on performance on O-3 fitness reports or promotion. For the combined population, undergraduate major is either negative or insignificant (compared to an engineering major), indicating that engineering majors fare well in all categories. Math and management majors fare the worst, with negative effects on two of the four dependent variables. Math is the only major that is statistically significant for identifying performance

as a LT (O-3). It has a strong negative effect. Management major has the strongest negative effect on retention, perhaps indicating that officers with a management major find prospects in the civilian workforce more appealing than the Navy. It is not certain if management majors have greater general training which is more appealing to civilian employers than other majors, or if they find the worst "fit" with a Navy career. Interestingly, the effect of humanities major is insignificant for all dependent variables indicating that humanities majors fare as well as engineering majors in all categories. It is important to note that the humanities major is the smallest category in the combined population, represented by only two to three percent of the population. The insignificance is due in part to the small number of officers with a humanities major, but it is apparent that humanities majors performed as well as engineering majors in this study.

The results indicate that undergraduate major has a much different effect among OCS graduates than among scholarship graduates. Non-technical majors (social sciences, management, and humanities) have a strong positive effect on retention among OCS graduates, but a strong negative effect among scholarship graduates. As discussed in Chapter II, OCS graduates committed to the Navy during their junior year of college or later. Therefore, they selected the Navy over other potential employers. It is possible that many OCS graduates selected the Navy due to poor civilian job prospects.[26] Perhaps OCS graduates with non-technical majors were faced with the least appealing civilian job

[26] The reader should keep in mind that this study analyzes officers who entered the Navy from 1977 to 1985. Unemployment rates were much higher during this period than now, and college graduates did not have the tremendous range of employment options that are currently available to graduates.

prospects, and found the Navy to provide a suitable alternative, even after five years of service in the Navy.

Also, non-technical majors have a strong negative effect on completing the nuclear training pipeline among scholarship graduates, but no major has a significant effect among OCS graduates. The insignificance of major is due in part to little variation in the dependent variable. In this study, 92.5 percent of OCS graduates successfully completed the nuclear training pipeline, ranging from 268 (91.2 percent) of the biology/physical sciences majors to all 12 (100 percent) of the social sciences majors and all 16 (100 percent) of the management majors. 83.6 percent of scholarship graduates completed the nuclear training pipeline. In this study, OCS graduates have higher grades than scholarship graduates do, possibly indicating greater academic capability and therefore greater likelihood of completing the training pipeline. 25.9 percent of OCS graduates have greater than a 3.60 college GPA and 69.4 percent have greater than a 3.20 college GPA. This is compare to 12.2 percent and 40.1 percent of scholarship graduates.

OCS graduates with a math major fared the worst on O-3 fitness reports and appear to be the reason for the negative effect observed in the combined population. As shown in Table 4.1, math major is the only major with a statistically significant effect on "performance" in the combined and OCS population; however, no major has a significant effect among scholarship graduates. As shown in Appendix B, math majors make up approximately 10 percent of the population in all of the models. Again, it is interesting to note the effect of humanities major. Among OCS graduates, humanities majors are more likely to remain in the Navy and enjoy better promotion rates than engineering majors do.

It is the only major that has a statistically significant effect on promotion. No other major, in any of the analyses, has a significant effect on promotion.

Table 4.1. Marginal Effects of Undergraduate Major (with respect to ENGINEER) on Four Performance Measures by Commissioning Source

DEPENDENT VARIABLE	MODEL			
	Graduate	Performance	Retention	Promote
Combined Population				
Biology/Physical Sciences	-0.05			
Math/Computer Science		-0.10	-0.07	
Social Sciences	-0.09			
Management/Economics	-0.10		-0.13	
Humanities				
OCS Graduates Only				
Biology/Physical Sciences			0.06	
Math/Computer Science		-0.20		
Social Sciences			0.32	
Management/Economics			0.33	
Humanities			0.18	0.19
USNA and NROTC Graduates				
Biology/Physical Sciences	-0.07			
Math/Computer Science			-0.12	
Social Sciences	-0.12		-0.11	
Management/Economics	-0.15		-0.23	
Humanities			-0.21	

1. Effects calculated only for variables significant to at least the .10 level. Blank values indicate that the effect is insignificant.
2. Appendix A lists mean values used to calculate marginal effects, probit estimates, chi-square values and level-of-significance, and marginal effects.

In general, the three analyses indicate that undergraduate major is an important factor in explaining retention decisions and the likelihood of completing the nuclear training pipeline, but that major has an insignificant effect on performance as a junior officer or promotion to LCDR. Among scholarship graduates, it is apparent that an engineering major prepares an officer to complete the nuclear training pipeline and that

officers with engineering majors find a good "fit" with the submarine community. Among OCS graduates, non-technical majors are more likely to remain in the Navy. The insignificance of undergraduate major in determining likelihood of completing the nuclear training pipeline is partly due to little variation in the dependent variable, given that 92.5 percent of OCS graduates successfully complete the training pipeline.

B. COLLEGE GRADES (GPA)

The effect of college GPA, as shown in Table 4.2, provides some of the most interesting and surprising results in this study. The measures of "Math Proficiency" and "Technical Proficiency" are not included on Table 4.2. These measures are not the focus of this thesis, but are included in the models because they improve the ability of the models to predict the likelihood of the dependent variables. The probit estimates for these two measures are listed in Appendix A. "Math Proficiency" has a statistically significant negative effect on "Retention" for the combined and scholarship graduate sub-samples, but an insignificant effect on all other measures. "Technical Proficiency" has a statistically significant negative effect on "Retention" for OCS graduates, but is insignificant for all other measures.

For the combined population, and for scholarship graduates, grades have a positive effect on all four dependent variables and a particularly strong effect on the probability of promotion. For OCS graduates, grades have a statistically significant positive effect on retention and promotion probability, but an insignificant effect on performance on O-3 fitness reports and the likelihood of completing the nuclear training pipeline. Again, little

variation in the dependent variable affects the significance among OCS graduates. Only 7.5 percent OCS graduates fail to complete the nuclear training pipeline, and only 31.8 percent remain in the Navy until the O-4 board.

Table 4.2. Marginal Effects of College GPA on Four Performance Measures by Commissioning Source

DEPENDENT VARIABLE	MODEL			
	Graduate	Performance	Retention	Promote
Combined Population				
GPA				
5: 3.60-4.00	0.02	0.06	0.05	0.06
4: 3.20-3.59	0.03	0.06	0.05	0.09
3: 2.60-3.19	0.03	0.06	0.05	0.12
2: 2.20-2.59	0.04	0.06	0.05	0.14
1: 1.90-2.19	0.04	0.06	0.04	0.14
0: 0-1.89				
OCS Graduates Only				
GPA				
5: 3.60-4.00			0.05	0.07
4: 3.20-3.59			0.05	0.10
3: 2.60-3.19			0.05	0.12
2: 2.20-2.59			0.04	0.12
1: 1.90-2.19			0.04	0.12
0: 0-1.89				
USNA and NROTC Graduates				
GPA				
5: 3.60-4.00	0.03	0.06	0.05	0.05
4: 3.20-3.59	0.04	0.06	0.04	0.09
3: 2.60-3.19	0.05	0.06	0.04	0.12
2: 2.20-2.59	0.06	0.06	0.04	0.14
1: 1.90-2.19	0.06	0.06	0.04	0.15
0: 0-1.89				

1. Effects calculated only for variables significant to at least the .10 level. Blank values indicate that the effect is insignificant.
2. Appendix A lists mean values used to calculate marginal effects, probit estimates, chi-square values and level-of-significance, and marginal effects.
3. The listed marginal effects represent the change in probability of the dependent variable when GPA changes from one category to the next. For example, in the combined population, as GPA increases from Category 4 (3.20-3.59) to Category 5 (3.60-4.00), the probability of promoting to LCDR increases by six percentage points.

Of note is the fact that GPA has a positive effect on retention for all submarine officers. Assuming that students with higher grades have greater employment opportunities available to them, this result suggests that individuals select a career on the basis of utility not just earnings. As discussed in Chapter II, individuals choose careers based on job satisfaction and other forms of intrinsic rewards such as respect earned, power, and the joy involved in doing what one considers important, as well as on financial considerations.

Presumably, more able officers (with higher grades) can earn greater financial rewards in the civilian workforce than other officers, but these more able officers are also more likely to be successful in the Navy. Perhaps, as grades improve, indicating greater motivation and/or cognitive skills, officers find greater satisfaction in the submarine force than they expect to find in a civilian job, which leads them to forego the potential of greater financial rewards in another job. This greater satisfaction could be due to the fact that the more capable and motivated the officer is, the more success he will enjoy on the job, and the less frustration he will experience.

Also interesting is the fact that the effect of GPA is linearly related to "Performance" and "Retention," but that the relationship is non-linear for "Graduate" and "Promotion." The reason for this result is not clear. Again, it is important to consider the distribution of officers across the various categories. As shown in Appendix B, well over 90 percent of submarine officers have higher than a 2.60 GPA, making up the top three categories of GPA, and fewer than one percent possess lower than a 2.20 GPA which

makes up the bottom two categories of GPA. Also, OCS graduates tend to have higher grades than scholarship graduates.

Figures 4.1, 4.2, and 4.3 graphically display the effect of GPA on the four dependent variables. As noted before, GPA is linearly related to "Performance" and "Retention", whereas the relationship is non-linear for "Graduate" and "Promotion."

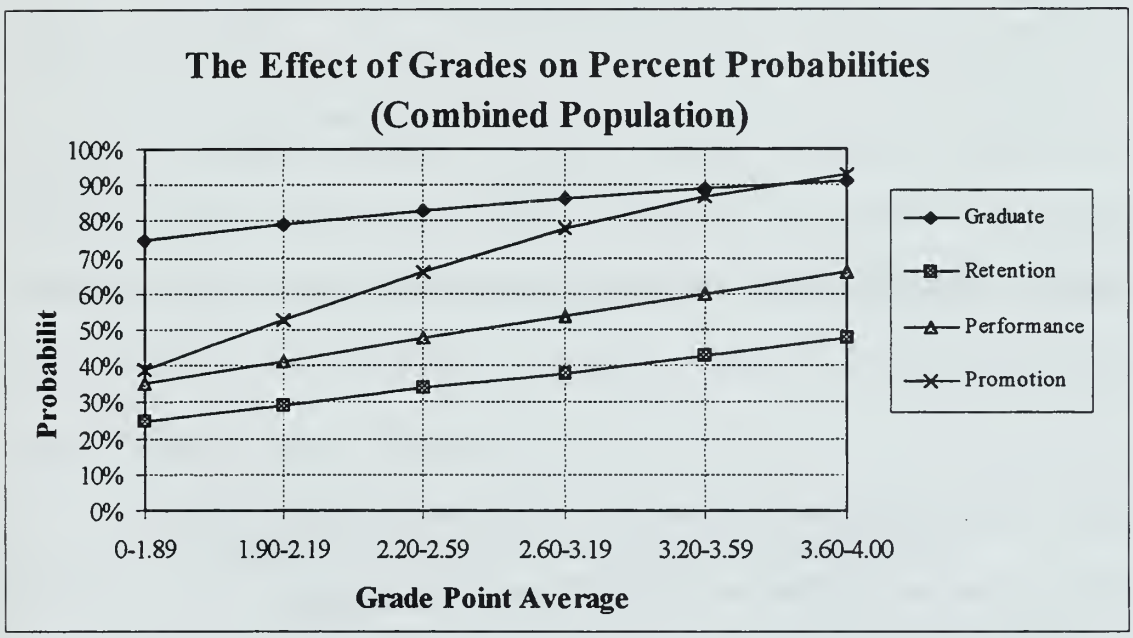

Figure 4.1 The Effect of GPA on Four Performance Measures for the Combined Population

Among OCS graduates, college GPA is only significant in explaining performance on O-3 fitness reports and promotion to LCDR. Figure 4.2 graphically displays the effect of GPA on "Performance" and "Promotion." For scholarship graduates, GPA has a statistically significant effect on all four performance measures. Figure 4.3 graphically displays the effect of GPA on the dependent variables.

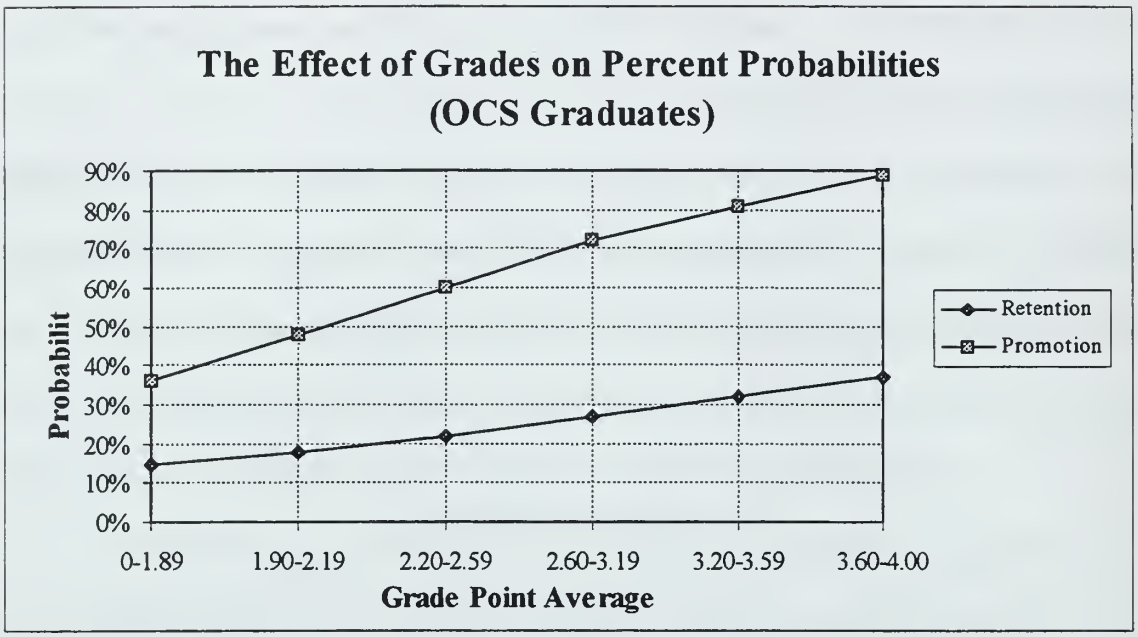

Figure 4.2 The Effect of GPA on Four Performance Measures for OCS Graduates

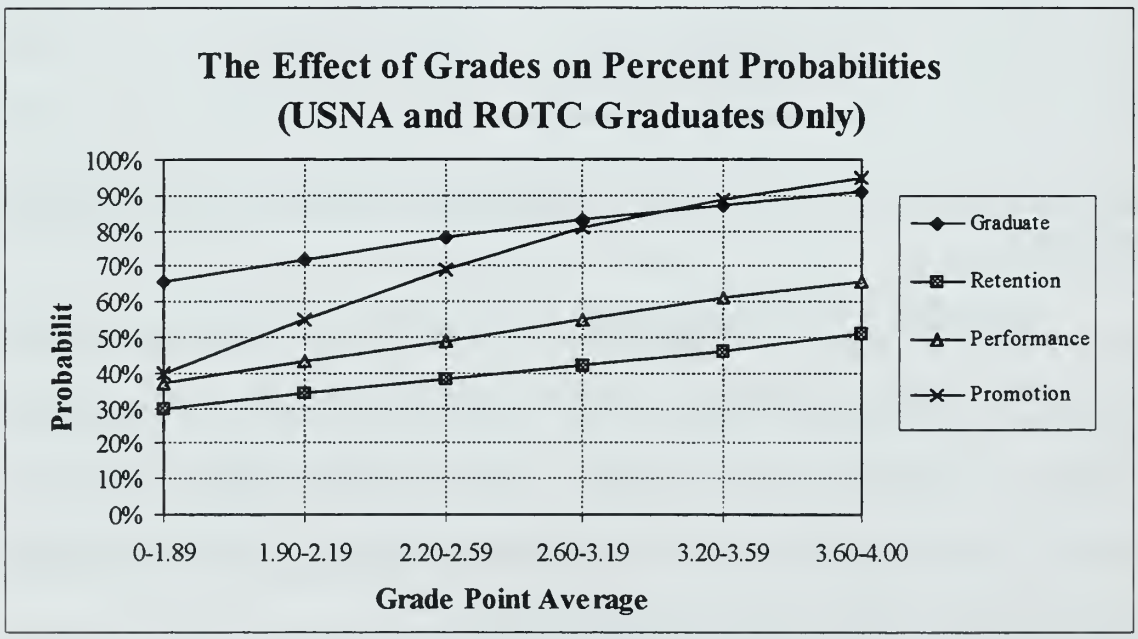

Figure 4.3 The Effect of GPA on Four Performance Measures for USNA and NROTC Graduates

C. COMMISSIONING SOURCE AND COLLEGE QUALITY

As shown in Table 4.3, commissioning source and college quality significantly affect submariner performance and retention. The two variables are interacted to specifically describe an officer's source. For example, rather than just indicating an officer is from the NROTC or OCS program, the interaction term allows the reader to see the effect of an officer coming from a NROTC program at a highly selective institution. Again, the objective of this thesis is to identify which officers (based on information available to recruiters) are likely to perform well as submariners and remain in the Navy. It is not of interest (in this study) to determine the effect of an individual commissioning source, but rather to determine the combined effect of commissioning source and college quality. However, from the results it is possible to approximate the relative effects of commissioning source and college quality.

The effect of commissioning source is evident by examining the overall NROTC and OCS results. In general, OCS graduates are more likely to complete the nuclear training pipeline than NROTC and USNA graduates, but are less likely to perform well on O-3 fitness reports and less likely to remain in the Navy. There is no discernible difference between NROTC and OCS graduates for the probability of promoting to LCDR, but graduates of both commissioning sources are less likely to promote than USNA graduates. Also, both NROTC and OCS graduates perform worse on O-3 fitness reports and are less likely to remain in the Navy than USNA graduates. The effect of NESEP is insignificant on all measures, except for a positive effect on "Retention." Because NESEP graduates are mostly prior enlisted members, it is not surprising that NESEP has a positive effect on

"Retention." NESEP graduates are closer to reaching 20 years of service in the Navy (the point of voluntary retirement with benefits) and they chose to become officers after experiencing Navy life as an enlisted person. Therefore, they chose to become a submarine officer with greater knowledge of what to expect from the future.

The effect of college quality is important to the Navy because it is more expensive to send NROTC candidates to, and recruit OCS candidates from, more selective institutions. College quality's effect on the dependent variables can be estimated by comparing the individual marginal effects of officers within one commissioning source category. For example, among OCS graduates, compare the difference between marginal effects for "high selectivity," "medium selectivity," and "low selectivity." This analysis indicates that OCS graduates from more selective institutions are more likely to perform well ("Graduate," "Performance," and "Promotion"), and are less likely to remain in the Navy ("Retention") than OCS graduates from less selective institutions. NROTC graduates from more selective institutions also are more likely to perform well than those from less selective institutions, but are equally likely to remain in the Navy. It is possible that college quality has a lesser impact on retention rates among NROTC graduates (compared to OCS graduates) due to a greater propensity towards service in the Navy. NROTC graduates committed to service in the Navy as they entered college whereas OCS graduates did not commit until their junior year of college or later. Again, it is important to consider the distribution of officers among the various categories. As displayed in Appendix B, NROTC graduates tend to come from more selective institutions with approximately 40 percent falling into the "high selectivity" category. The opposite is true

for OCS graduates. Nearly 50 percent of OCS graduates fall into the "low selectivity" category.

Table 4.3 Marginal Effects of Commissioning Source and College Quality on Four Performance Measures by Commissioning Source

DEPENDENT VARIABLE	MODEL			
	Graduate	Performance	Retention	Promote
Combined Population (with respect to USNA)				
NROTC high selectivity		-0.06	-0.10	
NROTC medium selectivity	0.04			-0.09
NROTC low selectivity		-0.10	-0.10	-0.08
OCS high selectivity	0.13	-0.01	-0.21	
OCS medium selectivity	0.10	-0.10	-0.21	-0.07
OCS low selectivity	0.08	-0.17	-0.13	-0.12
NESEP			0.15	
OCS Graduates Only (with respect to High Selectivity)				
OCS medium selectivity				
OCS low selectivity	-0.03		0.08	
USNA and NROTC Graduates (with respect to USNA)				
NROTC high selectivity			-0.09	
NROTC medium selectivity	0.05			-0.09
NROTC low selectivity	0.04	-0.09	-0.09	-0.08

1. Effects calculated only for variables significant to at least the .10 level. Blank values indicate that the effect is insignificant.
2. Appendix A lists mean values used to calculate marginal effects, probit estimates, chi-square values and level-of-significance, and marginal effects.

D. DEMOGRAPHIC VARIABLES

Finally, the effects of the demographic variables, prior enlisted experience and ethnicity, are listed in Table 4.4. Prior enlisted officers make up approximately ten percent of the combined population, ranging from two percent for scholarship graduates to approximately 20 percent of OCS graduates. Very few submarine officers are a racial minority, making up only two to three percent of the population in all analyses.

Generally, officers with prior enlisted experience are more likely to perform well on O-3 fitness reports and stay in the Navy; however, prior enlisted experience does not have a statistically significant effect on the probability of promotion to LCDR. It is not surprising that prior enlisted officers perform better on O-3 fitness reports due to the fact that they have greater "naval" experience. It is expected that they are more likely to remain in the Navy because they made the choice to enter a commissioning program after becoming familiar with life in the Navy. Also, they are closer to achieving 20 years in the Navy (the point of voluntary retirement) than other officers. Apparently the positive effect of prior enlisted experience is negligible after ten years of commissioned service, as evidence by the insignificant effect on promotion probability. It can be expected that after ten years in the Navy, other officers without enlisted experience have acquired the Navy-specific knowledge necessary to perform as well as officers with enlisted experience. Curiously, prior enlisted officers from USNA and NROTC are less likely to complete the nuclear training pipeline than those without enlisted experience; whereas, OCS graduates with enlisted experience are more likely to complete the training pipeline. The reason for this effect is not known.

Minority status is only significant among OCS graduates. It has a statistically significant negative effect on "Performance" and "Retention," but is insignificant for all other measures. Among OCS graduates, minorities are less likely to perform well on O-3 fitness reports and are less likely to remain in the Navy. The effect of minority status is not the focus of this thesis, but is included as a standard demographic control variable.

Table 4.4. Marginal Effects of Demographic Variables on Four Performance Measures by Commissioning Source

DEPENDENT VARIABLE	MODEL			
	Graduate	Performance	Retention	Promote
Combined Population				
>2 years enlisted experience		0.12	0.11	
Minority				
OCS Graduates				
>2 years enlisted experience	0.05	0.16		
Minority		-0.38	-0.18	
USNA and NROTC Graduates				
>2 years enlisted experience	-0.18			
Minority				

1. Effects calculated only for variables significant to at least the .10 level. Blank values indicate that the effect is insignificant.
2. Appendix A lists mean values used to calculate marginal effects, probit estimates, chi-square values and level-of-significance, and marginal effects.

In summary, a strong academic background, as evidenced by good grades, leads to higher completion rates through the nuclear training pipeline, better performance on O-3 fitness reports, and higher retention and promotion rates. Undergraduate major can be used to predict officer performance and retention decisions on an aggregate level. Technical aptitude appears to be beneficial, as engineering majors fare well on all four performance measures. However, it seems that it is the type of person that selects various majors, not technical aptitude, that is the most important factor. As evidence, math majors, though considered to possess a high degree of technical aptitude, fare the worst.[27]

[27] Math majors obviously possess great proficiency in math-related subjects, but do not necessarily receive schooling in engineering-related subjects, which provide knowledge useful toward understanding nuclear power. The U.S. Naval Academy groups its mathematics major with physics, chemistry, oceanography, and computer science as Category II majors. Engineering majors (these include aerospace, astrospace, electrical, mechanical, marine, ocean, systems, and naval architecture) are listed as a Category I major.

They are less likely to remain in the Navy and they perform worse on O-3 fitness reports than engineering majors. It is the only major than has a statistically significant effect on performance as an O-3. Among OCS graduates, non-technical majors have the highest retention rates. Humanities majors have higher retention and promotion rates than engineering majors do.

Officers from the Naval Academy fare better on all performance measures except "Graduate." Among OCS and NROTC graduates, college selectivity is an important factor. In both cases, graduates from more selective institutions are more likely to perform well on O-3 fitness reports and are more likely to promote to LCDR. For OCS graduates, higher selectivity leads to worse retention rates, but for NROTC graduates, selectivity does not have a strong effect on retention decisions.

V. CONCLUSIONS AND RECOMMENDATIONS

This chapter summarizes the conclusions drawn from the empirical analysis of this thesis. The chapter also proposes recommendations for further research into the effects of academic background on officer performance, and concludes with a discussion of the policy implications associated with this study's results.

A. CONCLUSIONS

In general, the results of this study support the emphasis that the submarine community places on selecting officers with stellar academic records and proven technical aptitude. Of all the naval communities, the submarine force is the only community that has the luxury to select which officers it desires based on academic background. Given the highly skewed distribution of submarine officers weighted towards engineering majors and good grades, it is encouraging to note that these factors (engineering majors and good grades) have a positive effect on virtually all measures of performance. In fact, the effects of other undergraduate majors are either negative or insignificant (compared to an engineering major) in all cases with the exception that OCS graduates with non-technical and biology/physical sciences majors are more likely to remain in the Navy. As noted before, the positive effect of GPA on retention decisions is both surprising and exciting. GPA has a positive effect in all cases with the exception of an insignificant effect on "Graduate" and "Performance" for OCS graduates. Not only is the submarine force able to select the more capable officers (capability based on college grades), but is able to keep them in the Navy too.

To summarize the results, a strong academic background, as evidenced by good grades, leads to higher completion rates through the nuclear training pipeline, better performance on O-3 fitness reports, and better retention and promotion rates. GPA has a particularly strong positive effect on the probability of promoting to LCDR. For OCS graduates, grades have a statistically significant positive effect in all cases with the exception of an insignificant effect on the likelihood of completing the nuclear training pipeline and performance on O-3 fitness reports.

Undergraduate major can be used to predict officer performance and retention decisions on an aggregate level. Technical aptitude appears to be beneficial, as engineering majors fare well on all four performance measures. However, math majors fare the worst. They are less likely to remain in the Navy and they perform worse on O-3 fitness reports than engineering majors. It is the only major that has a statistically significant effect on performance as an O-3. It has a strong negative effect. Among OCS graduates, non-technical majors have the highest retention rates and no major has a statistically significant effect on completing the nuclear training pipeline. Humanities majors have better retention and promotion rates than engineering majors do. The effect is opposite for scholarship graduates. For the USNA and NROTC subset, non-technical and math majors have the worst retention rates; and biology/physical sciences, social sciences, and management/economics majors have the worst training pipeline completion rates.

The findings suggest that the submarine force should continue to emphasize good grades and a strong technical background. On the other hand, non-technical majors from

the NUPOC program (OCS graduates) have compared favorably to engineering majors in both "Performance" and "Retention." They should not be excluded from recruiting efforts. Vice Admiral McGann, Commander Naval Recruiting Command (CNRC), recently directed NUPOC recruiters to extend their recruiting efforts beyond the usual search for college students in technical majors. The results of this thesis support a policy that encourages efforts to recruit non-technical majors into the NUPOC program.

The positive effect of an engineering major and good grades on measures of officer performance ("Graduate," "Performance," and "Promotion") support labor economics theories which state that investments in human capital (in this case evidenced by undergraduate major and level of GPA) lead to greater worker productivity. Additionally, it is apparent that engineering majors receive training that is useful as a submarine officer. However, it is unclear whether the positive effect of an engineering major and good grades on "Retention" is due to intrinsic rewards such as job satisfaction, a better "fit" with the submarine lifestyle, or some other unobserved factors. It is expected that officers with good grades, especially those with technical majors, have greater employment opportunities available to them in the civilian workforce, and will therefore be more likely to leave the Navy. However, the opposite is true. Good grades lead to higher retention rates.

Commissioning source and college selectivity significantly affect all four performance measures. Officers from the Naval Academy fare better on all performance measures except "Graduate." USNA graduates are more likely to perform well and are more likely to remain in the Navy than both NROTC and OCS graduates. NROTC

graduates perform slightly better than OCS graduates and also are slightly more likely to remain in the Navy. It is assumed that USNA graduates incur the greatest amount of specific training that is useful as a naval officer. Therefore, according to labor economics theory, it is not surprising that they perform better, and it can be expected that they will be more likely to remain in the Navy. Not only did they evince a propensity to serve in the Navy upon graduation from high school; but, having received the greatest amount of firm-specific training, human capital theory states that their earnings potential (or job productivity) is greatest with the Navy, relative to NROTC and OCS graduates.

Among OCS and NROTC graduates, college selectivity is an important factor. In both cases, graduates from more selective institutions are more likely to perform well on O-3 fitness reports and are more likely to promote to LCDR. For OCS graduates, higher selectivity leads to lower retention rates, but for NROTC graduates, selectivity does not have a strong effect on retention decisions. Also, for OCS graduates, greater selectivity leads to higher training pipeline completion rates. It has little effect on NROTC graduates' probability of completing the training pipeline.

B. RECOMMENDATIONS FOR FURTHER RESEARCH

Given the highly academic nature of the process used to select candidates into the submarine force, it is expected that the variables used in this thesis are the most important in identifying future success. However, there are many other factors that are likely important in identifying officer candidates who are likely to perform well as submariners.

It would be interesting, and of possible importance, to analyze the effects of other college characteristics, such as participation in athletics or other extracurricular activities.

Other studies, which analyzed the effects of an array of characteristics on officer performance, have found a strong correlation between non-academic characteristics and performance. For example, Matt Reardon (1997), analyzed the criteria that the Naval Academy uses to select which high school students to offer admission. Despite the academy's heavy reliance on academic measures as screening tools, Reardon found that factors such as participation in varsity athletics and leadership roles in other extracurricular activities had greater impact on performance as a midshipman and as an officer than academic measures did. In fact, achievement of Eagle Scout status had the strongest effect on future performance as an officer. Additionally, he analyzed the system that the academy uses to determine class rank among midshipmen. Again it is heavily weighted towards academic achievement, but he found that performance grades (a measure of leadership ability, maturity, and many other factors important as an officer) have a stronger correlation with future success as an officer than measures of academic achievement did.

As stated several times, the purpose of this thesis is to test the submarine force's policy of emphasizing a strong academic background and to provide recruiters with information that can be used to identify candidates which are likely to perform well as submarine officers. In that light, it is not the objective of this thesis to isolate the effect of self-selection bias. However, further research can utilize more sophisticated statistical techniques in an attempt to isolate self-selection bias and determine if it has a significant

effect on performance as an officer. Given the selective nature of the submarine community, it is expected that self-selection bias has a statistically significant effect. Also, further research is needed to analyze more recent year groups in order to determine if academic achievement continues to be an important factor in identifying success as an officer.

C. POLICY IMPLICATIONS

As stated before, the primary objective of this research is to provide NUPOC recruiters with information that identifies what type of college student is well suited for service in the submarine force. The results of this study accomplish this objective with respect to an individual's academic background, but do not address other important factors.

The strong positive effect of college GPA on all measures of performance supports the submarine force's policy of emphasizing academic ability in the screening of candidates. Surprising, and exciting, is the fact that GPA has a positive effect on retention decisions. The submarine force is able to recruit and retain the officers who possess the greatest academic ability. Also, the positive effect of engineering majors on most performance measures supports the submarine force's emphasis on a strong technical background. However, among OCS graduates, engineering majors are less likely to remain in the Navy than non-technical majors are.

Some specific recommendations:

- Broaden the scope of NUPOC recruiting efforts. Among OCS graduates, non-technical majors compare favorably with engineering majors. Non-technical majors are more likely to remain in the Navy and they perform equally well on the other performance measures as indicated by the insignificant effect of non-technical majors on "Graduate," "Performance," and "Promotion." Actually, humanities majors have a statistically significant positive effect on "Retention" and "Promotion." Despite the positive effect of non-technical majors, only 6.6 percent of the OCS graduates analyzed in this study have non-technical majors.
- Provide a more realistic "job preview" to NUPOC candidates. The OCS graduates in this study received only a one-day tour of a submarine base and a submarine. Despite the fact that they would eventually spend 50 percent of their time at sea as submarine officers, most of the OCS graduates had never been to sea on a Navy warship before committing to five years of service in the Navy. A short period of time at sea, similar to USNA and NROTC summer cruises, would provide NUPOC candidates with a more accurate description of what it is like to be a submarine officer. It is likely that this would result in higher retention rates among OCS graduates. It is even possible that it could serve as a highly effective recruitment tool that increases the number of college students who are interested in a career in the submarine force.
- Closer examination of mathematics and computer science majors. In this study, despite the fact that math and computer science majors should possess the academic aptitude to perform well as a submariner, it is the only undergraduate major category with a negative effect on performance as an O-3. Also, it is the only major category

that does not have a statistically significant effect on "Retention" among OCS graduates. All other categories of undergraduate major have a positive effect on "Retention" with respect to engineering majors. Because math and computer science majors meet the academic requirements for selection into the submarine force, recruiters target these majors for potential NUPOC candidates. It is not certain why math and computer science majors do not perform well in the submarine force, but an in-depth analysis of these majors may provide some insight. Perhaps the typical mathematics or computer science curricula provide inadequate preparation necessary to succeed as a submarine officer.

- Increase commissioning opportunities for enlisted personnel. Prior enlisted experience has a positive effect on performance as an O-3 and on retention decisions. Prior enlisted officers are more likely to perform well on O-3 fitness reports and are more likely to remain in the Navy than officers without significant enlisted experience are. This result is not surprising considering prior enlisted officers are handpicked from among the ranks of enlisted personnel. Under close observation as sailors, they have displayed attributes that are desirable as an officer, and they have displayed a propensity towards a career in the Navy.

This thesis provides information that can improve submarine force recruitment efforts based on academic background, as well as recommendations for research to improve recruitment efforts based on factors other than academic background. In general, the results of this study support the submarine force's emphasis on good grades and a strong technical background, but there are a few exceptions.

APPENDIX A

Appendix A lists the empirical results of the statistical analyses. The tables on the following pages list the mean values of the variables in each model, which are used to calculate marginal effects. For example, when calculating the marginal effects of various undergraduate majors, all other variables are held at the mean value and a one is inserted for the major of interest and a zero in all of the other majors. Therefore, the marginal effects represent the percentage point change in the dependent variable for a one-unit change in each of the independent variables. Marginal effects are calculated only for variables that are significant to at least the .10 level. Effects are not calculated for commissioning year dummy variables (not of interest) and for "Math Proficiency" and "Technical Proficiency." The effect of GPA is discussed at length in Chapter IV, presenting the marginal effects over the range of possible values.

Also included on the tables are: the number of observations for each model; the number of officers meeting the criteria for the dependent variable to equal one; and a measure of model fit, Chi-Square, which measures the likelihood that the included explanatory variables, in the aggregate, have a significant effect on the outcome of the dependent variable.

Table A.1.a. Results of GRADUATE model for Combined Population

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	.6215	8.7504	-
Demographics				
>2 years enlisted experience	.0866	.0747	.2885	-
Minority	.0277	-.1817	1.4347	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.2128	-.2183	9.3003***	-0.05
Math/Computer Science	.0936	-.0565	.2598	-
Social Sciences	.0328	-.3799	6.3376**	-0.09
Management/Economics	.0328	-.4348	8.8006***	-0.10
Humanities	.0207	.1354	.3539	-
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.1099	.0517	.3454	-
NROTC medium selectivity	.0777	.1752	2.6927*	0.04
NROTC low selectivity	.0782	.1579	2.2310	-
OCS high selectivity	.0443	.8072	19.1414***	0.13
OCS medium selectivity	.1093	.5413	24.7069***	0.10
OCS low selectivity	.1242	.4007	15.7269***	0.08
NESEP	.0297	.1336	.3660	-
Commissioning Year (with respect to FY77)				
FY78	.118	-.1655	1.6664	-
FY79	.1278	-.3773	9.3817***	-
FY80	.1102	-.1717	1.7772	-
FY81	.1351	.0559	.1858	-
FY82	.1152	-.3462	7.5771***	-
FY83	.0566	.2004	1.3444	-
FY84	.111	-.2566	3.8355**	-
FY85	.1399	-.5727	20.8635***	-
Academic Achievement				
GPA (values range from 0 to 5)	3.5753	.1382	11.7292***	.03
Math Proficiency (0 to 6)	4.5304	.000438	.0001	-
Technical Proficiency (0 to 5)	3.4914	.0438	2.1880	-

Number of Observations: 3567 (Y=1 for 3076 or 86.2 percent)
Chi-Square: 173.1 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.1.b. Results of GRADUATE model for OCS Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	1.5088	7.5901	-
Demographics				
>2 years enlisted experience	.1534	.7876	8.5792***	0.05
Minority	.0212	.1434	.0751	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.2967	-.1090	.5392	-
Math/Computer Science	.0928	.2327	.7645	-
Social Sciences	.0121	4.2939	.0000	-
Management/Economics	.0161	4.5649	.0000	-
Humanities	.0383	.0567	.0153	-
College Quality (with respect to high selectivity)				
medium selectivity	.3935	-.2168	1.0792	-
low selectivity	.4470	-.3838	3.5275*	-0.03
Commissioning Year (with respect to FY77)				
FY78	.0969	.7545	3.5294*	-
FY79	.1181	-.0385	.0145	-
FY80	.0747	-.0179	.0027	-
FY81	.1100	.3601	1.0598	-
FY82	.0858	.1940	.2999	-
FY83	.0595	.6676	1.7367	-
FY84	.1342	-.0716	.0497	-
FY85	.2735	-.2016	.4511	-
Academic Achievement				
GPA (values range from 0 to 5)	3.9122	-.0227	.0593	-
Math Proficiency (0 to 6)	4.5156	-.0161	.0271	-
Technical Proficiency (0 to 5)	3.5328	.0687	1.5132	-

Number of Observations: 991 (Y=1 for 917 or 92.5 percent)
Chi-Square: 38.7 (p=0.0072)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies.

Table A.1.c. Results of GRADUATE model for USNA/NROTC Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	.3562	1.9266	-
Demographics				
>2 years enlisted experience	.0211	-.6136	10.0484***	-0.18
Minority	.0308	-.2175	1.7368	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.1854	-.277	10.7693***	-0.07
Math/Computer Science	.0947	-.1725	1.8043	-
Social Sciences	.0421	-.4464	7.4275***	-0.12
Management/Economics	.0393	-.5598	12.3217***	-0.15
Humanities	.0146	.00644	.0005	-
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.1587	.0569	.4078	-
NROTC medium selectivity	.1121	.2044	3.5186*	0.05
NROTC low selectivity	.1130	.1826	2.8886*	0.04
Commissioning Year (with respect to FY77)				
FY78	.1235	-.3466	5.5605**	-
FY79	.1296	-.4925	11.7995***	-
FY80	.1219	-.2618	3.1365*	-
FY81	.1478	-.0238	.0257	-
FY82	.1316	-.4848	11.5156***	-
FY83	.0563	.0966	.2480	-
FY84	.1053	-.2596	2.8620*	-
FY85	.0911	-.6116	16.4051***	-
Academic Achievement				
GPA (values range from 0 to 5)	3.4478	.182	13.6434***	.04
Math Proficiency (0 to 6)	4.5409	.0593	1.1673	-
Technical Proficiency (0 to 5)	3.4660	.0417	1.2821	-

Number of Observations: 2470 (Y=1 for 2064 or 83.6 percent)
Chi-Square: 139.3 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.2.a. Results of PERFORMANCE model for Combined Population

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-.6999	12.0798	-
Demographics				
>2 years enlisted experience	.0947	.3122	6.0841**	0.12
Minority	.0258	-.0908	.3041	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.2012	-.0687	.9686	-
Math/Computer Science	.0939	-.2451	5.4274**	-0.10
Social Sciences	.0292	.0951	.2969	-
Management/Economics	.0300	-.1305	.6018	-
Humanities	.0227	-.081	.1573	-
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.1023	-.1462	2.5736*	-0.06
NROTC medium selectivity	.0785	-.0145	.0204	-
NROTC low selectivity	.0750	-.254	6.0699**	-0.10
OCS high selectivity	.0473	-.33	6.5051**	-0.01
OCS medium selectivity	.1104	-.2587	7.8536***	-0.10
OCS low selectivity	.1293	-.4314	22.9353***	-0.17
NESEP	.0308	-.0409	.0424	-
Commissioning Year (with respect to FY77)				
FY78	.0981	.0406	.1053	-
FY79	.1197	.2167	3.2582	-
FY80	.1066	.3901	10.3526*	-
FY81	.1435	.5094	19.4865***	-
FY82	.1154	.8042	43.8583***	-
FY83	.0723	1.6139	111.2801***	-
FY84	.1177	1.1071	78.3045***	-
FY85	.1508	1.0530	75.5787***	-
Academic Achievement				
GPA (values range from 0 to 5)	3.6068	.1558	16.9500***	.06
Math Proficiency (0 to 6)	4.5375	-.0248	.3668	-
Technical Proficiency (0 to 5)	3.5156	-.0162	.3423	-

Number of Observations: 2599 (Y=1 for 1466 or 56.4 percent)
Chi-Square: 378.5 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.2.b. Results of PERFORMANCE model for OCS Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-.6889	2.1303	-
Demographics				
>2 years enlisted experience	.1783	.4108	6.9284***	0.16
Minority	.0214	-1.0472	7.9750***	-0.38
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.2694	.0819	.4213	-
Math/Computer Science	.0952	-.5047	6.5702***	-0.20
Social Sciences	.0134	.0779	.0239	-
Management/Economics	.0201	.4751	1.3397	-
Humanities	.0456	.0324	.0088	-
College Quality (with respect to high selectivity)				
medium selectivity	.3847	.0638	.1843	-
low selectivity	.4504	-.1347	.8339	-
Commissioning Year (with respect to FY77)				
FY78	.0670	-.2790	.5999	-
FY79	.1180	.00938	.0008	-
FY80	.0617	.3425	.9654	-
FY81	.1166	.4324	1.7825	-
FY82	.0912	.9661	8.3452***	-
FY83	.0777	1.5996	19.7104***	-
FY84	.1394	1.2864	15.3123***	-
FY85	.2962	.9579	9.5650***	-
Academic Achievement				
GPA (values range from 0 to 5)	3.9129	.0851	1.4807	-
Math Proficiency (0 to 6)	4.4638	-.0181	.0659	-
Technical Proficiency (0 to 5)	3.4960	-.0327	.4849	-

Number of Observations: 746 (Y=1 for 420 or 56.3 percent)
Chi-Square: 163.0 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies.

Table A.2.c. Results of PERFORMANCE model for USNA/NROTC Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-1.1401	19.1906	-
Demographics				
>2 years enlisted experience	.0186	-.1514	.3970	-
Minority	.0282	.1955	1.0304	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.1777	-.1358	2.4174	-
Math/Computer Science	.0942	-.1935	2.1408	-
Social Sciences	.0367	.1839	.9075	-
Management/Economics	.0333	-.1205	.3967	-
Humanities	.0141	-.2392	.7239	-
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.1500	-.1292	1.9785	-
NROTC medium selectivity	.1151	.0117	.0129	-
NROTC low selectivity	.1100	-.2249	4.7062**	-0.09
Commissioning Year (with respect to FY77)				
FY78	.1083	.0850	.3603	-
FY79	.1168	.2811	4.0822**	-
FY80	.1201	.3934	8.2645***	-
FY81	.1574	.5235	16.0805***	-
FY82	.1303	.7571	30.9149***	-
FY83	.0711	1.7038	84.4768***	-
FY84	.1128	1.0375	51.8941***	-
FY85	.0953	1.2168	63.4896***	-
Academic Achievement				
GPA (values range from 0 to 5)	3.4907	.1515	9.6672***	.06
Math Proficiency (0 to 6)	4.5764	.0424	.5396	-
Technical Proficiency (0 to 5)	3.5217	.0192	.2771	-

Number of Observations: 1773 (Y=1 for 1000 or 56.4 percent)
Chi-Square: 247.8 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.3.a. Results of RETENTION model for Combined Population

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	.1351	.5591	-
Demographics				
>2 years enlisted experience	.0901	.2818	6.0828**	0.11
Minority	.0257	-.2146	1.9023	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.2094	.0123	.0371	-
Math/Computer Science	.0940	-.1944	3.9412**	-0.07
Social Sciences	.0283	-.1581	1.0145	-
Management/Economics	.0276	-.3526	4.7072**	-0.13
Humanities	.0218	-.0708	.1451	-
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.1070	-.2515	9.2128***	-0.10
NROTC medium selectivity	.0787	-.1297	1.9807	-
NROTC low selectivity	.0790	-.2481	7.0953***	-0.10
OCS high selectivity	.0491	-.5676	21.2596***	-0.21
OCS medium selectivity	.1180	-.5722	44.7260***	-0.21
OCS low selectivity	.1310	-.3429	17.3198***	-0.13
NESEP	.0309	.3851	4.2933**	0.15
Commissioning Year (with respect to FY77)				
FY78	.1190	-.0838	.6618	-
FY79	.1219	.0203	.0391	-
FY80	.1099	-.2725	6.6884***	-
FY81	.1421	-.2841	8.0384***	-
FY82	.1102	-.2556	5.8132**	-
FY83	.0611	1.5689	97.0502***	-
FY84	.1112	-.2997	7.8070***	-
FY85	.1349	-.5060	22.1326***	-
Academic Achievement				
GPA (values range from 0 to 5)	3.6086	.1250	12.6719***	.05
Math Proficiency (0 to 6)	4.5462	-.0771	4.1200**	-.03
Technical Proficiency (0 to 5)	3.5351	-.0418	2.6605	-

Number of Observations: 3076 (Y=1 for 1258 or 40.9 percent)
Chi-Square: 414.9 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. For Math Proficiency, the effect is calculated for a change from Cat4 to Cat5, again around the mean. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.3.b. Results of RETENTION model for OCS Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-.8565	4.7749	-
Demographics				
>2 years enlisted experience	.1625	.1146	.6220	-
Minority	.0218	-.6020	2.6499*	-0.18
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.2923	.1764	2.4195*	0.06
Math/Computer Science	.0949	-.1592	.7137	-
Social Sciences	.0131	.8384	3.4021*	0.32
Management/Economics	.0174	.8498	4.7728**	0.33
Humanities	.0393	.4813	2.3738*	0.18
College Quality (with respect to high selectivity)				
medium selectivity	.3959	-.0144	.0104	-
low selectivity	.4395	.2121	2.2912*	0.08
Commissioning Year (with respect to FY77)				
FY78	.1025	.0734	.0832	-
FY79	.1156	.5003	4.1114**	-
FY80	.0731	-.1249	.2089	-
FY81	.1134	.0281	.0125	-
FY82	.0872	.2899	1.2361	-
FY83	.0632	2.0635	39.0474***	-
FY84	.1320	-.0986	.1508	-
FY85	.2661	-.3147	1.7144	-
Academic Achievement				
GPA (values range from 0 to 5)	3.9062	.1463	5.0017**	.05
Math Proficiency (0 to 6)	4.5060	-.1182	3.1212*	-.04
Technical Proficiency (0 to 5)	3.5300	.0104	.0593	-

Number of Observations: 917 (Y=1 for 292 or 31.8 percent)
Chi-Square: 178.7 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. For Math Proficiency, the effect is calculated for a change from Cat4 to Cat5, again around the mean. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.3.c. Results of RETENTION model for USNA/NROTC Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-.1977	.7089	-
Demographics				
>2 years enlisted experience	.0165	.2438	1.0728	-
Minority	.0276	-.1145	.4118	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.1788	-.0546	.4673	-
Math/Computer Science	.0945	-.3028	6.2654**	-0.12
Social Sciences	.0359	-.2807	2.5744*	-0.11
Management/Economics	.0315	-.6293	10.8267***	-0.23
Humanities	.0150	-.5605	4.7453**	-0.21
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.1594	-.2375	8.1367***	-0.09
NROTC medium selectivity	.1172	-.1246	1.7999	-
NROTC low selectivity	.1177	-.2308	6.1074**	-0.09
Commissioning Year (with respect to FY77)				
FY78	.1231	-.0419	.1221	-
FY79	.1226	-.1484	1.5139	-
FY80	.1226	-.3047	6.3729**	-
FY81	.1579	-.3535	9.4947***	-
FY82	.1250	-.3812	9.9594***	-
FY83	.0610	1.4599	59.1900***	-
FY84	.1056	-.2794	4.9422**	-
FY85	.0819	-.3940	8.5531***	-
Academic Achievement				
GPA (values range from 0 to 5)	3.4869	.1121	6.2759**	.04
Math Proficiency (0 to 6)	4.5703	.0337	.4067	-
Technical Proficiency (0 to 5)	3.531	-.0575	2.9128*	-.02

Number of Observations: 2064 (Y=1 for 897 or 43.5 percent)
Chi-Square: 203.6 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. For Technical Proficiency, the effect is calculated for a change from Cat3 to Cat4, again around the mean. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.4.a. Results of PROMOTION model for Combined Population

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-.0621	.0404	-
Demographics				
>2 years enlisted experience	.1208	-.1634	.6376	-
Minority	.0231	-.2592	.9794	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.2083	-.1205	1.0857	-
Math/Computer Science	.0811	.2145	1.1751	-
Social Sciences	.0318	.2864	.8823	-
Management/Economics	.0270	-.1003	.1252	-
Humanities	.0278	.3189	.8697	-
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.0962	-.0394	.0632	-
NROTC medium selectivity	.0819	-.3485	4.9705**	-0.09
NROTC low selectivity	.0747	-.3088	3.5059*	-0.08
OCS high selectivity	.0358	-.3188	1.9304	-
OCS medium selectivity	.0795	-.2867	2.8930*	-0.07
OCS low selectivity	.1169	-.4411	8.4922***	-0.12
NESEP	.0548	-.3008	1.2129	-
Commissioning Year (with respect to FY77)				
FY78	.1256	-.0835	.2024	-
FY79	.1391	-.0564	.0975	-
FY80	.0978	.0504	.0649	-
FY81	.1200	-.00216	.0001	-
FY82	.0978	.1275	.3795	-
FY83	.1375	-.0738	.1592	-
FY84	.0938	-.2762	1.9551	-
FY85	.0835	-.4037	4.0612**	-
Academic Achievement				
GPA (values range from 0 to 5)	3.6089	.3528	32.3838***	.09
Math Proficiency (0 to 6)	4.4952	-.00758	.0131	-
Technical Proficiency (0 to 5)	3.4738	.0149	.1085	-

Number of Observations: 1258 (Y=1 for 1031 or 82.0 percent)
Chi-Square: 79.3 (p=0.0001)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.4.b. Results of PROMOTION model for OCS Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-.9929	1.7750	-
Demographics				
>2 years enlisted experience	.2226	-.1101	.1375	-
Minority	.0171	-.6624	1.1830	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.3185	-.0634	.0867	-
Math/Computer Science	.0651	.4360	.8516	-
Social Sciences	.0274	.9605	1.9029	-
Management/Economics	.0377	.8799	2.2298	-
Humanities	.0822	.9519	3.0919*	0.19
College Quality (with respect to high selectivity)				
medium selectivity	.3425	.0578	.0437	-
low selectivity	.5034	-.1235	.2223	-
Commissioning Year (with respect to FY77)				
FY78	.0890	-.1272	.0536	-
FY79	.1678	-.3212	.3890	-
FY80	.0852	.3214	.2538	-
FY81	.1027	.1088	.0380	-
FY82	.1027	.2787	.2393	-
FY83	.1815	-.1493	.0822	-
FY84	.1062	-.2816	.2580	-
FY85	.1541	-.7447	2.0514	-
Academic Achievement				
GPA (values range from 0 to 5)	3.8767	.3156	8.4949***	.10
Math Proficiency (0 to 6)	4.2089	.1425	1.3820	-
Technical Proficiency (0 to 5)	3.2055	.0386	.2162	-

Number of Observations: 292 (Y=1 for 227 or 77.7 percent)
Chi-Square: 28.5 (p=0.0985)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. Effects are presented for the range of possible GPA values in Chapter IV.

Table A.4.c. Results of PROMOTION model for USNA/NROTC Graduates

VARIABLE	Mean	Probit Estimate	Chi-Square[1]	Marginal Effect[2]
Intercept	1	-.3620	.7498	-
Demographics				
>2 years enlisted experience	.0201	-.3667	1.1663	-
Minority	.0256	-.1029	.1109	-
Undergraduate Major (with respect to Engineering)				
Biology/Physical Sciences	.1839	-.1615	1.2666	-
Math/Computer Science	.0858	.1326	.3132	-
Social Sciences	.0346	.2664	.5446	-
Management/Economics	.0212	-.3447	.9594	-
Humanities	.0123	.2284	.1607	-
Commissioning Source interacted with College Quality (with respect to USNA)				
NROTC high selectivity	.1349	-.0547	.1183	-
NROTC medium selectivity	.1148	-.3494	4.7866**	-0.09
NROTC low selectivity	.1048	-.3282	3.8806**	-0.08
Commissioning Year (with respect to FY77)				
FY78	.1371	.1425	.4320	-
FY79	.1237	.1465	.4453	-
FY80	.1037	.1345	.3472	-
FY81	.1304	.0942	.1889	-
FY82	.1026	.1825	.6063	-
FY83	.1293	.1210	.3075	-
FY84	.0948	-.2080	.8574	-
FY85	.0658	-.1087	.1865	-
Academic Achievement				
GPA (values range from 0 to 5)	3.5632	.3737	19.5311***	.09
Math Proficiency (0 to 6)	4.5964	-.0001	.0000	-
Technical Proficiency (0 to 5)	3.5552	.0399	.4412	-

Number of Observations: 897 (Y=1 for 753 or 84.0 percent)
Chi-Square: 51.9 (p=0.0002)

[1] *** Significant at the .01 level; ** Significant at the .05 level; * Significant at the .10 level

[2] Marginal effects only calculated for variables that are significant to at least the .10 level, and are not calculated for commissioning year dummies. The marginal effect of GPA represents a change from Cat3 (2.6-3.2) to Cat4 (3.2-3.6) which is around the mean value. Effects are presented for the range of possible GPA values in Chapter IV.

APPENDIX B

Appendix B provides information on the distribution of officers in various important explanatory variable categories. Both the actual number of officers and the corresponding percentage are listed.

Table B.1 Distribution of Officers in the Combined Population

Category	Graduate		Performance		Retention		Promotion	
Total Number (N=...)	3567		2599		3076		1258	
	#	%	#	%	#	%	#	%
Met criteria for Y=1	3076	86.2	1466	56.4	1258	40.9	1031	82.0
Demographics								
>2 years enlisted	309	8.7	246	9.5	277	9.0	152	12.1
Minority	99	2.8	67	2.6	79	2.6	29	2.3
Undergraduate Major								
Bio/Physical Sciences	759	21.3	523	20.1	644	20.9	262	20.8
Math/Computer Sci	334	9.4	244	9.4	289	9.4	102	8.1
Engineering	2166	60.7	1619	62.3	1904	61.9	785	62.4
Social Sciences	117	3.3	76	2.9	87	2.8	40	3.2
Management	117	3.3	78	3.0	85	2.8	34	2.7
Humanities	74	2.1	59	2.3	67	2.2	35	2.8
Commissioning Source								
USNA	1522	42.7	1108	42.6	1250	40.6	579	46.0
NROTC	948	26.6	665	25.6	814	26.5	318	25.3
OCS	991	27.8	746	28.7	917	29.8	292	23.2
NESEP	106	3.0	80	3.1	95	3.1	69	5.5
Academic Achievement								
GPA								
5: 3.60-4.00	577	16.2	452	17.4	525	17.1	236	18.8
4: 3.20-3.59	1146	32.1	839	32.3	1013	32.9	388	30.8
3: 2.60-3.19	1619	45.4	1157	44.5	1364	44.3	547	43.5
2: 2.20-2.59	204	5.7	136	5.2	158	5.1	80	6.4
1: 1.90-2.19	19	0.5	15	0.6	15	0.5	7	0.6
0: 0-1.89	2	0.1	0	0.0	1	0.0	0	0.0

Table B.2 Distribution of OCS Graduates

Category	Graduate		Performance		Retention		Promotion	
Total Number (N=…)	991		746		917		292	
	#	%	#	%	#	%	#	%
Met criteria for Y=1	917	92.5	420	56.3	292	31.8	227	77.7
Demographics								
>2 years enlisted	152	15.3	133	17.8	149	16.2	65	22.3
Minority	21	2.1	16	2.1	20	2.2	5	1.7
Undergraduate Major								
Bio/Physical Sciences	294	29.7	201	26.9	268	29.2	93	31.9
Math/Computer Sci	92	9.3	71	9.5	87	9.5	19	6.5
Engineering	539	54.4	415	55.6	498	54.3	137	46.9
Social Sciences	12	1.2	10	1.3	12	1.3	8	2.7
Management	16	1.6	15	2.0	16	1.7	11	3.8
Humanities	38	3.8	34	4.6	36	3.9	24	8.2
College Quality								
High Selectivity	158	15.9	123	16.5	151	16.5	45	15.4
Medium Selectivity	390	39.4	287	38.5	363	39.6	100	34.3
Low Selectivity	443	44.7	336	45.0	403	43.9	147	50.3
Academic Achievement								
GPA								
5: 3.60-4.00	257	25.9	202	27.1	241	26.3	87	29.8
4: 3.20-3.59	431	43.5	313	42.0	390	42.5	107	36.6
3: 2.60-3.19	270	27.2	203	27.2	253	27.6	79	27.1
2: 2.20-2.59	25	2.5	20	2.7	25	2.7	13	4.5
1: 1.90-2.19	8	0.8	8	1.1	8	0.9	6	2.1
0: 0-1.89	0	0.0	0	0.0	0	0.0	0	0.0

Table B.3 Distribution of USNA and NROTC Graduates

Category	Graduate		Performance		Retention		Promotion	
Total Number (N=...)	2470		1773		2064		897	
	#	%	#	%	#	%	#	%
Met criteria for Y=1	2064	83.6	1000	56.4	897	43.5	753	84.0
Demographics								
>2 years enlisted	52	2.1	33	1.9	34	1.6	18	2.0
Minority	76	3.1	50	2.8	57	2.8	23	2.6
Undergraduate Major								
Bio/Physical Sciences	458	18.5	315	17.8	369	17.9	165	18.4
Math/Computer Sci	234	9.5	167	9.4	195	9.4	77	8.6
Engineering	1541	62.4	1142	64.4	1330	64.4	594	66.2
Social Sciences	104	4.2	65	3.7	74	3.6	31	3.5
Management	97	3.9	59	3.3	65	3.1	19	2.1
Humanities	36	1.5	25	1.4	31	1.5	11	1.2
College Quality (for NROTC)								
High Selectivity	392	41.4	266	40.0	329	40.4	121	38.1
Medium Selectivity	277	29.2	204	30.7	242	29.7	103	32.4
Low Selectivity	279	29.4	195	29.3	243	29.9	94	29.6
Academic Achievement								
GPA								
5: 3.60-4.00	301	12.2	237	13.4	269	13.0	138	15.4
4: 3.20-3.59	690	27.9	509	28.7	600	29.1	264	29.4
3: 2.60-3.19	1305	52.8	919	51.8	1069	51.8	437	48.7
2: 2.20-2.59	164	6.6	103	5.8	120	5.8	57	6.4
1: 1.90-2.19	8	0.3	5	0.3	5	0.2	1	0.1
0: 0-1.89	2	0.1	0	0.0	1	0.0	0	0.0

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